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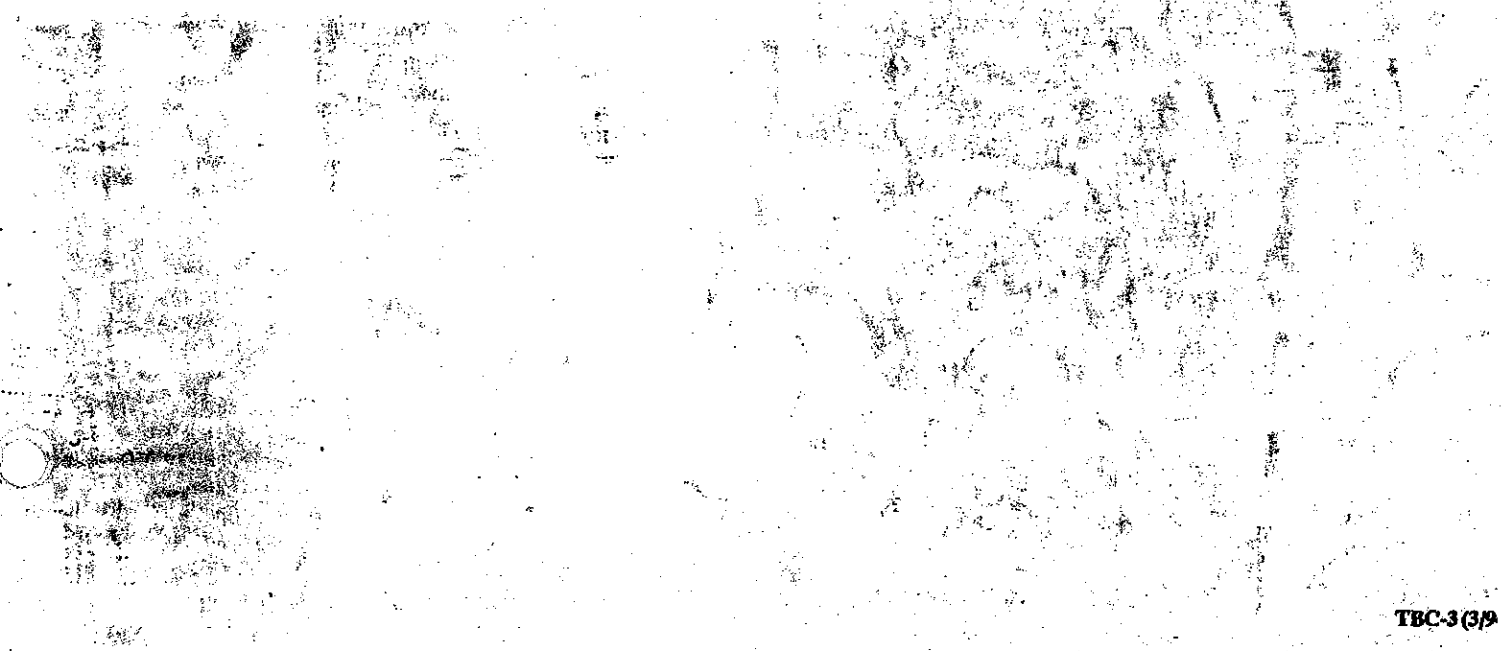

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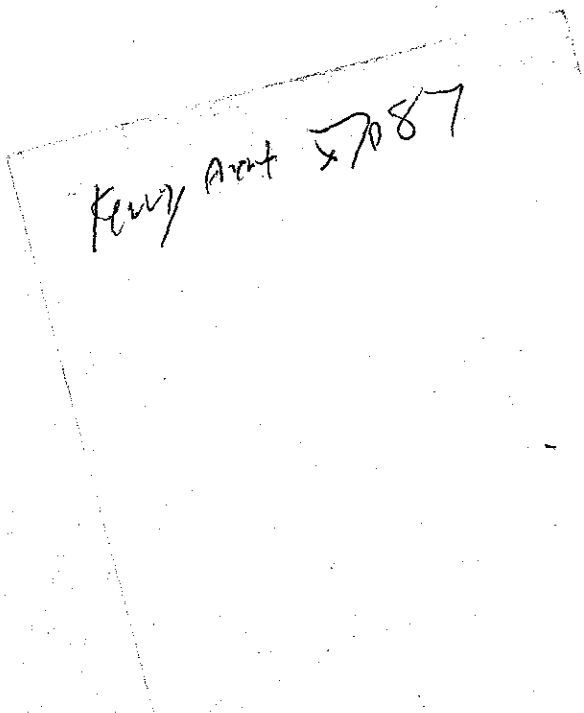

3M Infusion Therapy Warranty and Service Policy & Service Agreement Options

3M Infusion Therapy Limited One Year Warranty

3M Infusion Therapy (3M) warrants that for one year following shipment its Infusion Device will be free of defects in manufacture and material. 3M also warrants that this Infusion Device is fit for use in accordance with its written instructions. **However, 3M does not warrant that this device is fit for any other particular purpose. This warranty does not apply if the device has been altered, misused, or repaired by persons not authorized by 3M.**

Limitation Of Remedies

If, within one year after shipment, this device is defective in manufacture or material, 3M will repair or replace the device or, at 3M's option, refund the purchase price. To obtain warranty service, you must request a Returned Material Authorization (RMA) number from the 3M Infusion Therapy Service Center. Reference the RMA number when returning your Infusion Device, freight and insurance prepaid, to 3M Infusion Therapy Service Center, 3800 North Dunlap, St. Paul, Minnesota 55112-6933. The repaired or replaced Infusion Device will be shipped, freight prepaid, to you.

THESE ARE YOUR ONLY REMEDIES. 3M WILL NOT BE LIABLE FOR CONSEQUENTIAL OR INCIDENTAL DAMAGES OF ANY KIND.

Service

Bio Med Screen options 3031 7867

The 3M Infusion Therapy Service Center performs the following functions:

- Service and repair of all 3M Infusion Devices
- Technical assistance and consultation
- Preventive maintenance
- Technical training

Warranty service will be performed when in accordance with 3M Infusion Therapy's Warranty.

To initiate service and repair:

A. Contact the 3M Infusion Therapy Service Center at

1-800-752-7867 SIMS-DELTEC

Request a Returned Material Authorization (RMA) number. A purchase order will be requested before an RMA number is issued.

B. Clearly reference on all shipping documents:

- RMA number
- purchase order number
- written description of problem
- name and address of contact person within your hospital or organization

- complete name and return address of organization.

C. Carefully package the pump(s) in the original shipping carton, or other appropriate container, and affix a 3M "Returned Material" label to each carton shipped.

D. Ship the pump(s), freight prepaid, by traceable means, to

3M Infusion Therapy Service Center
3800 North Dunlap
St. Paul, MN 55112-6933

Service and repair is generally completed within 4 working days upon receipt by the service center. If you need a "Service Loaner" while your pump is being repaired, a loaner must be requested when calling in for the RMA number.

Any chargeable repairs on pumps under warranty or contract, or repairs estimated to exceed $150.00 on pumps out of warranty, will not be performed without customer authorization. If an "estimate is required before work is performed" state this when calling in for the RMA number. Pumps under warranty or contract are returned freight prepaid. Out of warranty pumps will also be returned freight prepaid, however a shipping/handling charge will be added to the repair/charge invoice. When other than normal means of shipment is requested by the customer, an additional charge is assessed depending upon the type of shipment requested.

Limited Service Warranty

3M Infusion Therapy (3M) warrants that all service and repair performed by the service center will be performed competently and in accordance with industry standards. 3M also warrants for a period of ninety (90) days that parts furnished by the service center will be free from defects in manufacture or material. **This warranty covers only that portion of the Infusion Device serviced in cases where a complete overhaul has not been performed.**

Limitation Of Remedies

If any failure to meet the Limited Service Warranty Policy appears within ninety (90) days following service or repair, 3M will correctly re-perform the service identified, repair or replace defective parts provided, replace the Infusion Device or, at 3M's option, refund the purchase price. To obtain warranty service, you must request a Returned Material Authorization (RMA) number from the 3M Infusion Therapy Service Center. Reference the RMA number when returning your Infusion Device, freight and insurance prepaid, to 3M Infusion Therapy Service Center, 3800 North Dunlap, St. Paul, Minnesota 55112-6933. The repaired or replaced Infusion Device will be shipped, freight prepaid, to you.

THESE ARE YOUR ONLY REMEDIES. 3M WILL NOT BE LIABLE FOR CONSEQUENTIAL OR INCIDENTAL DAMAGES OF ANY KIND.

Service Offerings

- Device Loaners
- Service Training Seminars
- Technical Assistance
- Preventive Maintenance Agreements
- Service Maintenance Agreements

Contact the 3M Infusion Therapy Service Center at 1-800-752-7867 for details.

SIMS-DELTEC

Section 1: General Description

1.1 3M Infusion Therapy Models 3000 & Micro 3100 System Description

The 3M Modular Infusion System consists of the Model 3000 and Micro 3100 infusion pumps used in conjunction with various 3M administration sets. The 3M Modular Infusion Systems are intended for use by trained medical professionals in the intravenous and intra-arterial delivery of fluid and medications. In addition, they may be used for epidural delivery (see 1.2, below). Both pumps offer user programmable control over both volume and rate at which the dose is delivered.

The key component of the administration set is the unique, flexible, three-chambered cassette. 3M administration sets may also be used for gravity administration independent of the pump due to their valveless design.

Precise control over delivery rate and volume is provided by the mechanical manipulation of the flexible cassette. The pumping mechanism results in smooth fluid delivery to the patient.

The pumps provide for monitoring of several alarm/alert situations. In alarm situations, fluid delivery stops, an audible alarm sounds, and a visual alarm is displayed. In alert situations, a separate audible alarm sounds, an alert indicator is displayed, and fluid delivery continues. These alarm/alert indicators and audible alarms are fully explained in Section 3.5 and 3.6.

The Model 3000 and Micro 3100 also offer several optional features. These include Rate Tapering and Quick Rate Change. In addition, Options allows you to check battery life, total volume delivered over several infusions, time remaining this infusion, and a feature which allows you to continuously light the display panel for easier reading in darkened rooms. The Biomedical Special Functions are designed to aid service personnel in troubleshooting and recordkeeping.

Both pumps can be used for secondary (piggyback) delivery when used with a checkvalve and piggyback administration set, switching automatically from secondary to primary rate and volume. The pumps are typically attached to an IV pole using the built in pole clamp. The patented Modular Connection System allows you to connect up to 3 pumps together for easy use when multiple infusion lines are required. The pumps can be used on AC power, or with the built-in battery. Battery power allows you to continue infusion even if AC power fails or is accidentally cut off. Battery power also provides portability for ambulatory patients.

1.2 Epidural Administration

The Model 3000 and Micro 3100 Infusion Pumps may also be used for epidural administration.

Anesthetics
Epidural administration of anesthetics is limited to short-term (not to exceed 96 hours) infusion with indwelling catheters specifically indicated for short-term epidural delivery of anesthetic drugs.

Analgesics
Epidural administration of analgesics is limited to use only with indwelling catheters specifically indicated for short- or long-term delivery of analgesic drugs.

- To prevent infusion of drugs not indicated for epidural use, do not use IV administration sets which contain injection sites.
- Differentiate the pump and IV set being used for epidural delivery from those being used for other routes of administration.

WARNING
When delivering drugs in the epidural space, use only those medications specifically indicated for epidural use. Epidural administration of other drugs could result in serious patient injury.

1.3 Precautions

DANGER
Never operate this pump on AC power while patient is bathing, showering, or otherwise immersed in liquid. Use of the pump under such conditions could lead to severe electric shock. If a pump must be used under such conditions, only DC (battery) power may be used to power the pump.

DANGER
Place the pump away from all flammable anesthetics to avoid explosion hazard.

DANGER
Electric shock hazard exists if pump housing is opened. Internal servicing should be performed only by qualified, 3M Infusion Therapy-trained personnel. Always unplug AC power cord before beginning disassembly.

WARNING
Replace fuses only with fuses of same type and rating to protect against fire hazard.

WARNING
The air detection system of the pumps are designed to detect air at the top of the cassette when the pump is used in the upright position. Do not lay the pump on its side or back during operation.

WARNING
The occlusion detection sensor detects downline back-pressure in the administration set, but is not designed to detect infiltration. In accordance with institution's policies and procedures, operator must periodically inspect patient's infusion site for swelling, temperature changes, and/or other signs of infiltration.

WARNING
Pump users should receive inservice training prior to beginning use of any medical equipment. Improper use of the pumps could lead to injury.

CAUTION
Electrostatically sensitive components are used in the design of the pumps. Protection against Electrostatic Discharge (ESD) must be provided when handling printed circuit boards.

CAUTION
Do not autoclave, ethylene oxide sterilize, or submerge this pump in any liquid or pump damage will occur.

CAUTION
To avoid unnecessary Occlusion alarms, do not exceed 200 millimeters of Mercury (mmHg) when using a pressure cuff above the patient's venipuncture site when using the Low Occlusion Alarm Setting, do not exceed 100 mmHg).

CAUTION
The Model 3000 and Micro 3100 require gravity to cause flow from the fluid container to the pump. For this reason, the pumps should not be used as part of an autotransfusion system in which blood is collected at a level below the pump.

CAUTION
Federal (USA) law restricts this device to use by or on the order of a physician or other licensed practitioner.

Section 2: Specifications

Model 3000 and Micro 3100

Table 2-1 lists operating and design specifications of the Model 3000 and Micro 3100 Infusion Pumps.

NOTE
All pump specifications are subject to change without notice.

Table 2-1 Pump Specifications

Specifications	Model 3000	Micro 3100
Rate Range	• 0.1 to 99.9 mL/h in 0.1 mL/h increments. • 1 to 999 mL/h in 1 mL/h increments.	0.1 to 99.9 mL/h in 0.1 mL/h increments.
Volume to be Infused Range	• 0.1 to 999.9 mL in 0.1 mL increments. • 1 to 9999 mL in 1 mL increments.	0.1 to 999.9 mL in 0.1 mL increments.
Accuracy	± 2% of displayed Rate and Volume to be Infused.	Same.
Weight	Approximately 5 kg (11 pounds).	Same.
Dimensions	Approximately: Height 25 cm (10 inches). Width 15 cm (6 inches). Depth 16 cm (6.5 inches).	Same.
Free-Flow Protection	Mechanism operates 3M administration set Safety Clip.	Same.
AC Power	Factory configured for 115 or 230 Volts AC, depending on country of destination.	Same.
Over-Current Protection	.200 amp AC line fuse for use with 115V AC, two .080 amp AC line fuses for use with 230V AC, 130° thermal fuse within transformer, 1.0 amp battery fuse. All fuses are time delay.	Same.
Leakage Current	Less than 20 or 50 microamps ungrounded (depending on voltage), measured between ground stud and protective earth (ground).	Same.
Battery Type	Rechargeable, sealed lead-acid, 12 volt, 1.3 Ah.	Same.
Battery Capacity	Approximately 6 hours at 100 mL/h, with approximately 1/2 hour warning of depleted battery.	Approximately 6 hours at 99.9 mL/h, with approximately 1/2 hour warning of depleted battery.
Battery Recharge	Approximately 10 hours (pump may be operated while recharging).	Same.
Head-Height (*from bottom of drip chamber to top of pump*).	6 inches minimum for rates less than 500 mL/h.	6 inches minimum.
	12 inches minimum for rates greater than 500 mL/h, when using 60 dps/mL sets, and/or with highly viscous solutions.	12 inches minimum when using 60 dps/mL sets, and/or with highly viscous solutions.
Occlusion Alarm Setting	Approximately: Selectable. Low = 2 psi/100mmHg Medium = 5 psi/250 mmHg High = 10 psi/500 mmHg.	Same.
Warning **The occlusion detection sensor is designed to detect downline backpressure in the administration set, but is not designed to detect infiltration. In accordance with institution's policies and procedures, operator must periodically inspect patient's infusion site for swelling, temperature changes, and/or other signs of infiltration.**		
KVO Rate	3 mL/h, or selected rate if less than 3 mL/h.	Same.
Self Test	Dual microprocessors independently test each other.	Same.

Section 3: Installation & Operation

3.1 Installation

1. AC Power Connection

The 3M Model 3000 and Micro 3100 Infusion Pumps are equipped with a detachable power cord, which has a three-prong, hospital grade plug. The power cord is designed to minimize leakage current inducing potentials on the ground wire.

The power cord is secured to the rear housing during manufacture, but can be removed from the pump should safety testing of the cord itself become necessary. A cord retainer is attached over the cord by four screws. The cord retainer must be reinstalled whenever the cord is reattached or replaced, or ground and power connections may become unreliable.

If the cord becomes damaged, replace it immediately. Replacements should be made using original equipment in order to maintain grounding safety and acceptable level of leakage current. Integrity of the three-prong plug is also important to prevent electric shock. Do not use extension cords, adapter plugs, or attempt to defeat the plug's ground connection. Always hold the plug itself when unplugging the power cord, as pulling on the cord could damage plug connections.

2. Portable Operation & Modular System

The pumps are equipped with a 12 volt battery for portable operation, or in the event AC power fails or is unavailable.

The infusion pumps may be operated while standing on any horizontal surface, provided the bottom of the administration set drip chamber is at least 6 inches above the top of the pump (12 inches may be required on the 3000 with rates greater than 500 mL/h, or on both the Micro 3100 and 3000 when using 60 drops/mL sets and/or highly viscous solutions). Typically, however, the pump is attached to an IV pole using the pole clamp on the pump's rear housing. IV pole mounting and battery operation make the pumps portable for patient mobility.

The Model 3000 and Micro 3100 are equipped with a Modular Connection System which allows connection of up to 3 pumps for situations when multiple infusion lines are required. The Modular Connector System is designed so that any pump can be a Center, Left, or Right mounted pump. Only the Center pump (pump which is attached to IV pole) will accept attachment of another pump. This prevents connecting too many pumps, which could cause IV poles to tip.

3.2 Operational Description

The Model 3000 and Micro 3100 Infusion Pumps contain a central system controller microprocessor (CPU1), with two peripheral microprocessors used for display control (CPU3) and fail-safe system monitoring (CPU2). The central microprocessor controls all user programmable functions, alarm condition sensors, and interprocessor communications.

The central microprocessor also controls a 4-phase stepping motor which is used to operate the pumping mechanism. Smooth fluid delivery is accomplished by uninterrupted forward rotation of the pumping mechanism when the pump is running.

When you open the door, the pumping mechanism "backs off" to the *load position*. The pistons are best positioned to accept a fluid filled cassette when in the *load position*. Completion of cassette loading results in some additional reverse rotation of the motor as pressure (which develops during the loading process) on the cassette is reduced and the pumping mechanism prepares for delivery. To facilitate upstream pressure release, the overpressure valve seals the lower fluid pathway during reverse rotation of the pumping mechanism and reopens upon initial forward rotation.

The Free-Flow Prevention System consists of the Safety Clip (located under the cassette on the administration set) and the mechanical clip retention slot and associated mechanics on the lower portion of the cassette housing. The Safety Clip must be placed in the clip retention slot when loading the cassette, or the pump will not operate. When the door is closed the Safety Clip opens to allow fluid delivery. When the door is opened, the Safety Clip closes over the lower tubing, thus preventing unrestricted fluid flow even when the administration set is removed from the pump.

WARNING
To minimize the possibility of unrestricted gravity flow, always close the lower roller clamp before opening the door.

The microprocessor stops the pump and sounds the ***insistent*** audio alarm when one or more of the following nine alarm conditions is detected (note - the actual messages displayed during an alarm condition are discussed in detail in Section 3.6):

- System Error/Warning
- Occlusion

- Air
- Empty Bag (no flow above pump)
- Door Open
- On Hold
- Dead Battery
- Safety Clip
- Pressure Plate Position Switch

Detection of the following four alert conditions will cause the microprocessor to sound the ***non-insistent*** audio alarm:

- On Battery
- Low Battery
- Rate Change Not Completed
- KVO (Keep Vein Open)

During these four alert conditions the pump will continue to run and the audio alarm can be silenced by pressing ***Silence*** or ***Run*** (see Section 3.6 for visual alarm descriptions).

Downline pressure is developed by the pumping pistons at the upper two cassette chambers, and is continuously monitored at the middle cassette chamber. Occlusion monitoring is performed by the pressure transducer mounted in the door assembly. The Occlusion alarm is activated if pressure exceeds the user selected threshold level. The pump briefly backs off to reduce downline pressure, which minimizes fluid bolus to the patient. At that point, the pump stops and fluid delivery ceases.

WARNING
The occlusion detection sensor detects downline back-pressure in the administration set, but is not designed to detect infiltration. In accordance with institution's policies and procedures, operator must periodically inspect patient's infusion site for swelling, temperature changes, and/or other signs of infiltration.

During operation, the rate and volume to be infused will be continuously shown in the Numeric Displays. The Message Display will show volume infused for the current infusion (as fluid is delivered, the Volume to be Infused display counts down as the volume in the Message Display counts up). Also, status lights will be appropriately lit to show the current status of the pump. When the pump is turned off, the data in the Message Display and Numeric Displays will be stored in nonvolatile memory and displayed again when the pump is turned on. The memory is maintained by a 3 volt lithium battery which is integrated with the memory chip.

The Running Rate Change feature allows you to instantly change rates without interrupting fluid delivery. Pressing ***Rate*** while the pump is operating readies the microprocessor to receive new rate input. After entering the new rate using the number keys, the new rate will appear in the display, but the pump will continue to infuse at the original rate. Press ***Run*** to lock in the new rate setting. If ***Run*** is not pressed within 10 seconds of entering the new rate, the original rate will reappear in the display, the ***non-insistent*** audio alarm will sound, and the Message Display will flash and display

```
Rate change
not completed
```

The Model 3000 and Micro 3100 have the capability to be programmed for automatic sequential delivery of two solutions. The secondary medication is delivered according to the secondary program of rate and volume to be infused selections. Then, rather than entering KVO after secondary delivery, the pump switches to Primary and delivers the primary solution according to a separate program. The KVO alarm occurs following delivery of the primary solution.

There are additional message and pumping options explained in the Options section of this manual.

3.3 Controls And Indicators

Front Panel Controls And Indicators
(Reference Figure 3-1.)

NOTE
Only those controls and indicators not specifically labeled as to function are called out using numbers below.

1. Message Display

The Message Display is an alphanumeric liquid crystal display, consisting of 2 lines by 16 characters. It shows infusion status, visual alarms, options, and other messages.

The Message Display is backlit when any key is pressed, and when the door is opened. The backlight will remain on for approximately 1 minute.

The backlight time out feature has different characteristics when the pump is on AC power and battery power:

AC Power
With the pump on hold, and with the door closed, the backlight will always be on. With the pump on hold, and with the door open, the backlight will time out after approximately 1 minute. After timeout, if the door is closed, the Message Display backlight will turn on.

DC Power (Battery)
When on battery power, the backlight will time out after approximately 1 minute whether the door is open or not.

When the pump is running, some messages are displayed briefly, then the display reverts to the standard message. The general rule is that informational messages will be

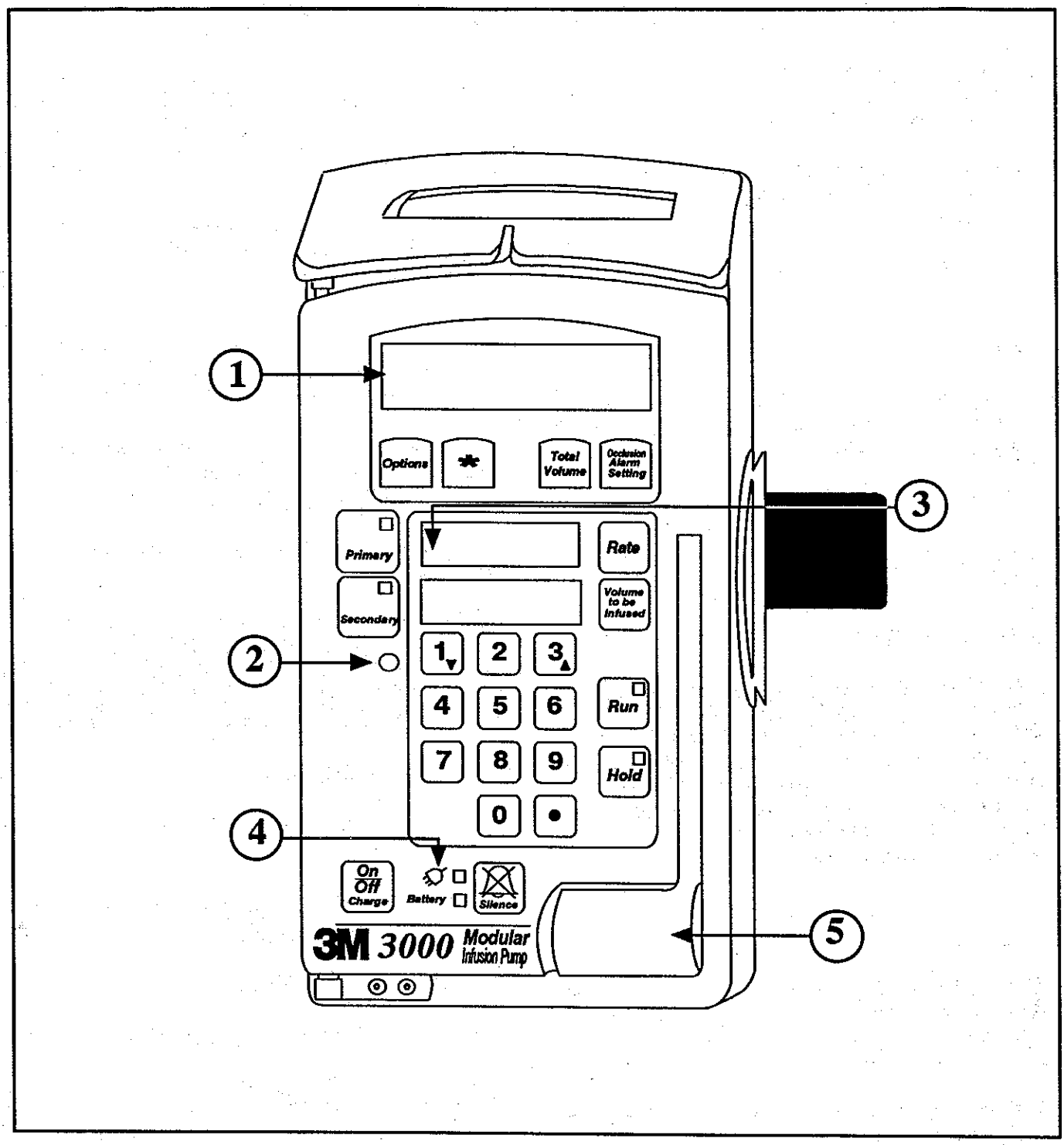

Figure 3-1
Front Panel Controls and Indicators

displayed for 5 seconds, and messages with instructions or which require input will be displayed for 10 seconds. Pressing a key which has a different display associated with it will cause its screen to be instantly displayed before the 5 or 10 second timeout has expired on the first message.

During an alarm or alert condition, the backlight will flash on and off with the audible alarms and remain on after the audio has been silenced.

The various Message Display screens are listed in Section 9.

Options Key

Pressing *Options* allows you to scroll through the optional functions. To select and set up desired option(s), follow the instructions in the Message Display .

⊠ Key

The ⊠ key is used in the programming of optional functions and when clearing Total Volume.

Total Volume Key

Press ***Total Volume*** to display the cumulative volume (Primary, Secondary, and Rate Taper) which has been delivered since it was last cleared. Total volume also displays total hours and minutes the pump has been in use since the display was last cleared. Total volume may be checked when the pump is running or on hold. With the pump on hold, the total volume and time will be shown in the Message Display as follows:

```
____mL   __h __m
Press * to clear
```

To clear total volume, press ***Total Volume***, then press ⊠. If ⊠ is not pressed, pressing any other key (except ***Options*** or ***Occlusion Alarm Setting***) will return the Message Display to the standard message.

With the pump running, the total volume and time will be displayed as follows:

```
____mL   __h __m
total infusions
```

The message remains for 5 seconds before reverting to the standard message. The pump must be on hold to clear Total Volume.

In either case, the time displayed is the time since total volume was last cleared. It includes all time during which the pump is turned on, whether on hold or running. If time exceeds 99 hours, 59 minutes, the display shows 100+hrs.

Occlusion Alarm Setting Key

With the pump on hold, repeatedly pressing ***Occlusion Alarm Setting*** advances through Low, Medium, and High occlusion settings in the Message Display. When the desired setting is shown in the Message Display, select it by pressing ***Run***.

While the pump is running, pressing ***Occlusion Alarm Setting*** shows the setting which is currently in use. However, the setting cannot be changed until the pump is placed on hold.

The Occlusion Alarm Setting determines the amount of downline pressure allowed in the administration set before the pump alarms.

Low means the pump will alarm when downline pressure reaches 100 mmHg (2 psi), Medium = 250 mmHg (5 psi), and High = 500 mmHg (10 psi).

The pump automatically defaults to the Medium setting when turned on.

The Low setting is designed to be used at lower infusion rates. When infusing at higher flow rates, with more viscous solutions, and/or with small diameter catheters, the "Occlusion below pump" alarm may activate. Change the Occlusion Alarm Setting if not appropriate for infusion.

Primary Key & Indicator

Selects primary delivery as shown by the green indicator light on the key.

If a secondary infusion is running, press ***Primary*** to view the primary settings momentarily.

Secondary Key & Indicator

Selects secondary delivery as shown by the yellow light.

Press ***Secondary*** while the primary line is running to view the secondary rate momentarily.

2. Photo Sensor

The photo sensor constantly measures room light and adjusts the intensity of the LED displays accordingly.

3. Pumping Indicator

Located on the left side of the Rate Display, the pumping indicator, consisting of three horizontal lines, moves in a downward fashion to indicate fluid delivery. The speed of the pumping indicator is approximately proportional to the rate.

Rate Key & Numeric Display

The Rate Numeric Display shows the rate, in mL/h, at which the current infusion is being delivered.

With the pump on hold, pressing ***Rate*** blanks the rate display and readies the pump for rate entry. If no new rate is entered the display will default to the old rate after approximately 10 seconds.

Volume to be Infused Key & Numeric Display

The Volume to be Infused Numeric Display shows the volume, in mL, which remains to be delivered. The display counts down from the initial setting when the pump is running.

With the pump on hold, pressing ***Volume To Be Infused*** blanks the display and readies the pump for volume to be infused entry. Pressing ***Volume to be Infused*** twice will restore the previously set Volume to be Infused.

Number Keys (0-9)

The number keys are used to set Rate, Volume To Be Infused, and when working in certain Options.

The 1 and 3 keys are also marked with up and down indicators for use during Quick Rate Change.

. (decimal) Key

Press the decimal key to enter rates and volumes in 10ths mL/h.

Run Key & Indicator

Press ***Run*** to begin infusing. The green indicator on the key will be lit steadily when fluid is being delivered at the programmed rate, and flashes when delivering at the KVO rate.

If the door is not closed, the administration set safety clip is not in place, or pump set up is incomplete, ***Run*** is disabled.

Run is also used to set a new rate during Running Rate Change.

Hold Key & Indicator

Pressing ***Hold*** stops the infusion or, if the pump is already on hold, temporarily silences an audio alarm. When the pump is on hold, the red indicator on the key will be lit.

When the pump is alarming, the indicator light on the key will flash until either ***Hold***, ***Silence***, or ***Run*** is pressed.

On/Off Key

On/Off is a software controlled switch. Pressing it activates the central microprocessor's power up and power down routine. On/Off is deactivated while the pump is running. Another switch is wired electrically parallel with On/Off so that opening the door when the pump is off will also turn the pump on. The pump cannot be turned off unless the door is closed.

DANGER
Potentially dangerous voltages are exposed whenever the pump housing is opened and the power cord is plugged in, regardless of the on or off state of the pump. These voltages are present in the following areas: the transformer and AC fuse on the CPU/power supply board, and the RFI filter where the power cord connects. Always unplug the AC power cord before beginning disassembly.

CAUTION
Turning the pump off removes power from most circuits, but does not remove AC power from the transformer. The transformer and 12 volt battery charging circuit are energized whenever the power cord is plugged in, regardless of on/off state.

Silence Key

Press ***Silence*** to silence the audio alarm. Silence can be used when it is undesirable or unnecessary to place the pump on hold (e.g., when a low battery alarm occurs and the pump must remain on battery operation for a short time before plugging it in).

4. (charge) Indicator

The green charge indicator lights when the pump is plugged in and the battery is charging, regardless of whether the pump is on or off.

Battery Indicator

The yellow Battery indicator is lit whenever the pump is being powered by the internal battery.

When battery power is low, the indicator will flash until the power cord is plugged in.

5. Door Latch (Handle)

Pulling the door latch to the open position moves the cam housing and pumping mechanism to the *load position*. This position is used to install the administration set or remove a set from the pump. Pushing the latch closed moves the pumping mechanism to the *operate position*.

If the pump is running and the door is opened, the

```
Door open
```

alarm is activated. Pressing ***Silence*** or ***Hold*** will silence the alarm.

Once a set is loaded into the pump and the safety clip is placed in the retention slot, closing the door opens the safety clip to allow for fluid delivery. When the door latch is pulled open, the safety clip is allowed to close, thus preventing gravity flow through the set.

CAUTION
To prevent pump and/or cassette damage, open the upper clamp on the administration set before closing the door.

Inside Pump Door
(Reference Figure 3-2.)

1. Cassette Loading Pins

Place four holes on cassette (flat side out) over four loading pins and press cassette into place.

2. Safety Clip Retention Slot

Place administration set Safety Clip in slot and push completely forward. Pump will not operate unless Safety Clip is correctly loaded.

Back Panel Controls
(Reference Figure 3-3.)

1. Alarm Volume Control

Turn to increase or decrease audio alarm volume. Audio alarm cannot be completely silenced.

2. Computer Port

This is an RS 232 Port for computer connection.

3. Keypad Lockout Button

Pressing the button activates (or deactivates) the Keypad Lockout feature. When the button is pressed, the message display will read `Keypad lockout`, and no keypad entries are allowed. After 5 seconds, the Message Display will timeout and revert to standard message.

Pressing the button again deactivates the lockout feature and restores all keypad functions. There is no change to the message display when the lockout feature is deactivated.

4. Ground Stud

The ground stud is used as a test point to measure leakage current and ground line resistance levels.

5. Pole Clamp

Turn the pole clamp clockwise firmly to secure the pump to an IV pole.

6. Modular Connection

The modular connection allows you to connect up to 3 pumps together for multiple infusion lines.

7. Modular Disconnect Button

Press to disconnect pumps from each other.

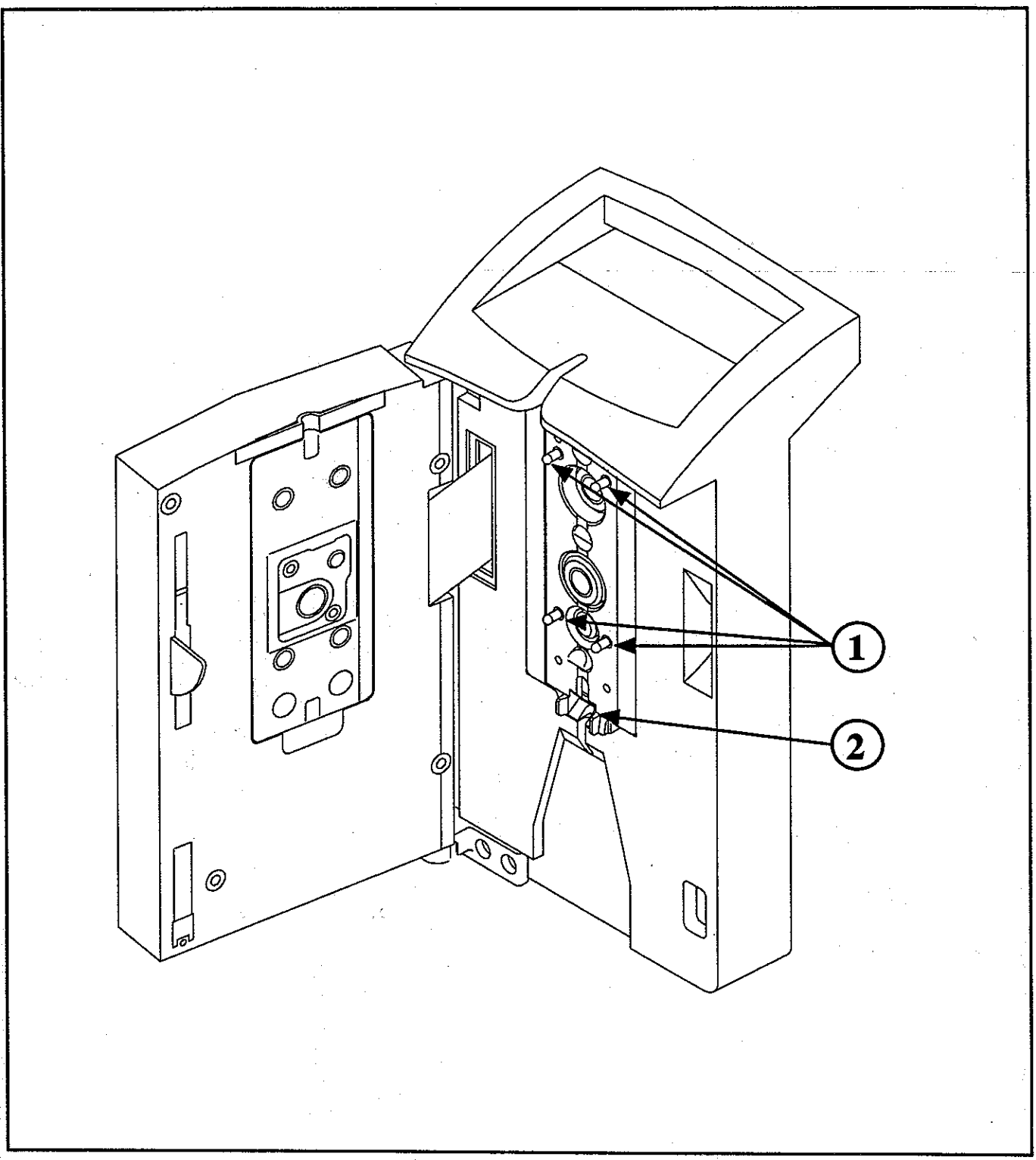

Figure 3-2
Inside Pump Door

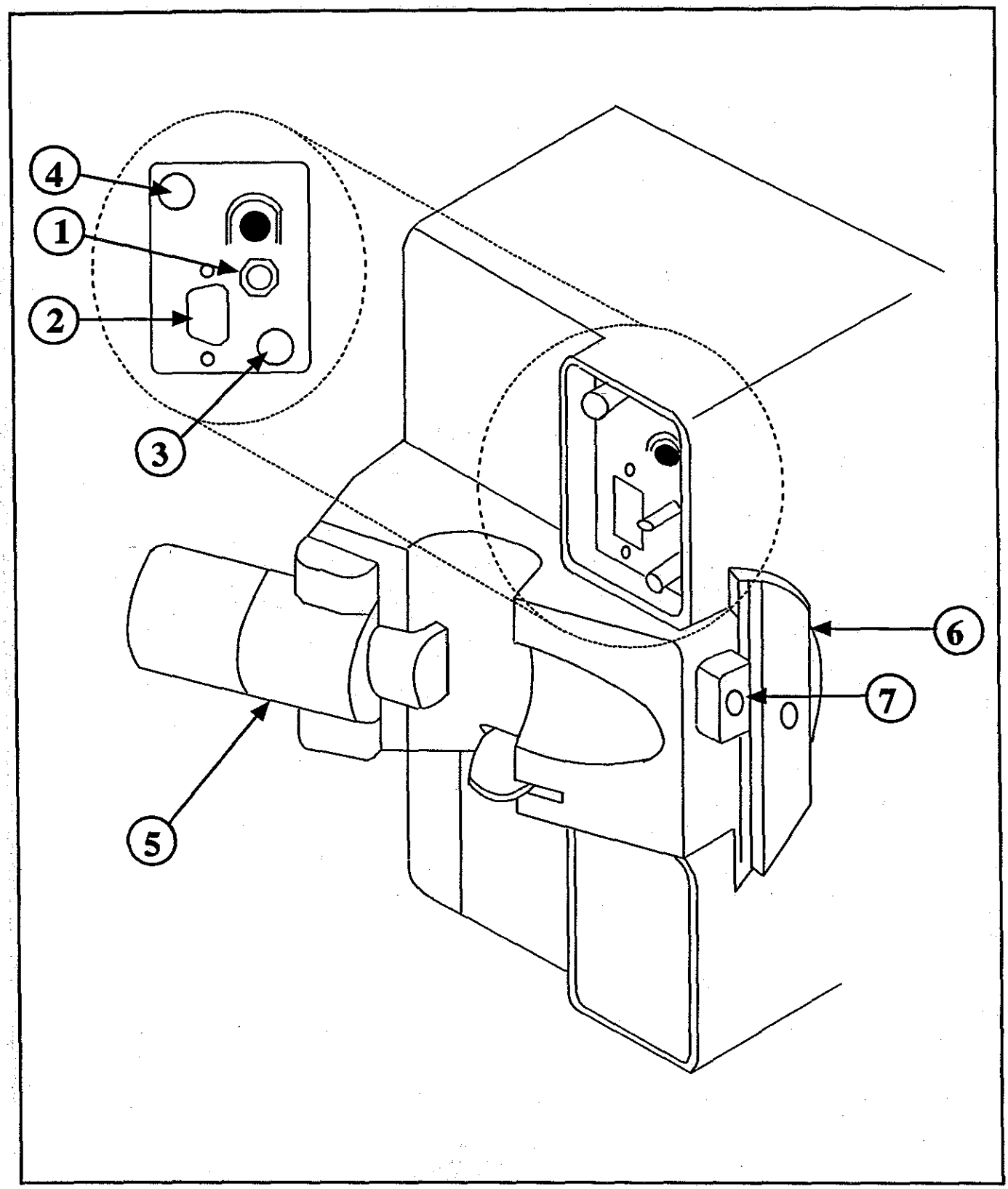

Figure 3-3
Back Panel Controls

3.4 Operating Modes

1.Power On

A. On/Off Switch

With the pump off, pressing ***On/Off*** turns the pump on. With the pump on and on hold, pressing ***On/Off*** turns the pump off. Another switch is wired electrically parallel with ***On/Off*** so that opening the door will also turn the pump on. The pump cannot be turned off unless the door is closed.

Door Open
When the door is opened to turn the pump on, or if it's opened while the pump is powering up, the hold light will not turn on until the motor has backed off to its home position. Rate and volume to be infused may be entered before the motor has completely backed off. If ***Run*** is pressed during the backoff, the motor will step forward (begin fluid delivery) once the motor is finished backing off.

B.Cold Boot Power Up

When the pump is turned on, it is considered a cold boot, and the following actions take place:

- The I/O ports of the microprocessors are initialized, placing all system components in startup configuration.
- A write/readback test is performed on non-volatile RAM.

NOTE
If this test fails, the following message is displayed and the software is locked allowing no further processing:

```
System Error:
No NV RAM
```

If the pump is plugged into AC power, the message remains until the pump is unplugged. If being powered by the battery, the message is displayed for 5 seconds, then the pump automatically turns off.

- A checksum comparison is performed on non-volatile ram, and, if it fails, system warning 13 is recorded for viewing in Biomedical Special Functions (see Section 3.8). A memory location is then checked to determine if the initialization was from a cold-boot or warm-boot (see next section on warm-boot power up).
- All CPU RAM locations are cleared.
- The main CPU computes a checksum of its ROM contents and compares this against a predetermined value.

NOTE
If a ROM checksum error occurs, the following message is displayed, and the software is locked allowing no further processing:

```
System Error:
ROM Checksum
```

If the pump is plugged into AC power, the message remains until the pump is unplugged. If being powered by the battery, the message is displayed for 5 seconds, then the pump automatically turns off.

- Timers, counters, registers, and interrupts are initialized for operation.
- Counters and timers are initialized for pump history information.
- A jumper wire is read determining whether the pump is micro-only (Model 3100) or micro/macro (Model 3000).
- Communication is established between the CPUs. Commands are exchanged signaling that initialization is completed and ROM checksums are correct.
- The keypad is scanned to determine whether ***Options*** was pressed along with ***On/Off***. If so, the pump enters Biomedical Special Function (see section 3.8).
- A display test is run. The numeric displays illuminate the number 8 in each digit with decimal points active. While the numeric displays are showing 8s, the pumping motion LEDs display the number 8, then go blank. The Message Display will show a checkerboard pattern. These tests last approximately 1 second.
- The microprocessor checks to see if the pump is operating on AC power or battery. If on AC power, the Charge light will already be lit. If on battery power, the Battery light will be lit, and the battery voltage will be checked to see if it is in operating range (> 11.6 volts DC).

  If the voltage is out of range (less than 11.6 volts), the pump will alarm low battery (as described in Section 3.5 of this manual).
- The motor monitor microprocessor runs a motor cutoff test to verify proper function of the motor driver shutoff, then backs the motor off to its home position.

NOTE
If the motor driver shutoff is not working, a system warning will be noted. The cold boot stops, a snapshot is taken, and the following system warning message is displayed:

```
System check
Turn off then on
```

- The Primary parameters are retrieved from memory and displayed. The Secondary parameters are stored and ready for display. Secondary volume to be infused defaults to zero and must be re-entered.
- A value is written in non-volatile memory as an

indicator that a cold boot process was completed.

- The pump enters hold. If the pump was turned off with a Rate Taper option set (but not delivered), the Message Display shows:

```
RUN to infuse
* Resets Taper
```

instead of the standard message:

```
___ mL
this infusion
```

If the pump was turned off during or after running a Rate Taper program, the display shows:

```
Taper ____ mL
this infusion
```

C. Warm Boot Power Up

A warm boot power up occurs if the microprocessor is reset when the pump is already in the on state. If a reset occurs the pump begins its power up initialization routine. During the power up routine, the microprocessor looks for a value in non-volatile memory normally stored during the pump's power down routine. Since the normal power down routine is not completed during a reset, the value is not found and the current routine is considered a warm boot. The rate display shows 0.1 and the volume to be infused display shows 0.0 if a RAM checksum failure occurs.

If a warm-boot occurs, the ***insistent*** audio alarm and a warm-boot system warning are activated:

```
System check
Turn off then on
```

2. Power Off

A. Manual Power Down

The pump can only be turned off by pressing ***On/Off*** while the door is closed. If the pump is running, you must first press ***Hold***, then ***On/Off***.

The master CPU stops pumping operations and all system components are disabled. The non-volatile memory is updated with checksums. At this point, if the pump is on AC power, it will continue to keep track of AC on time for the pump history. The green charge light will be lit, indicating that the battery is charging. If powered by the battery, a non-volatile memory location is initialized, indicating that a power down has occurred, after which the power turns off.

If the pump is operating on battery power, and if the pump is stuck in a fault mode where the CPU's are not operating properly, a special command (OFFCPU2, described in Section 4 under Power Control) allows On/Off to operate.

If the pump is connected to AC power, turned off, and the cord is then unplugged, the pump powers down completely after writing data to pump history.

B. Automatic Power Down

NOTE
The following information describes the automatic power down routines for pumps with revision 0.50 software. Pumps with software of revision 0.51 or higher will power down as described only when being powered by battery power. When these pumps are plugged in to AC power, they would have to be left alarming for approximately 72 hours before an automatic power down occurs. See Section 3.8, Biomedical Special Functions, for instructions on determining the software revision of your pumps.

If the pump is left on hold (following an alarm, or if left idle) for approximately 2.5 minutes with the door closed, the ***insistent*** audio alarm sounds. If the pump is left on hold with the door open, the pump alarms after approximately 6 minutes. In either case, if left alarming for an additional 12.5 minutes, the pump automatically shuts off.

If the battery status in the message display indicates

```
Battery too low
Plug in cord
```

the pump enters hold (if running), sounds the ***insistent*** audio alarm, and the hold light flashes. If left alarming, the pump will automatically turn off in 15 minutes, or when the battery reaches 10 volts.

3. Power Monitoring

A. AC Power

If the pump is plugged in, the charge light will be steadily lit. The software also records and stores in pump history the period of time that the pump is plugged in.

B. Battery Power

If there is a dropout in the voltage regulator due to AC line or component failure, the pump will automatically switch to battery power. The Battery light is steadily lit (unless the battery is low or dead, in which case it flashes), the charge light is off, and the period of time on battery will be recorded and stored in pump history.

Battery voltage levels are determined by:

Normal Operating Voltage: Voltage > 11.6, ± 0.1 volts

Low Battery: 11.0 < Voltage >/= 11.6, ± 0.1 volts

Dead Battery: 10.0 < Voltage >/=11.0, ± 0.1 volts

Automatic Turn Off: Voltage < 10.0 , ± 0.1 volts

Once a low battery state occurs (low battery, dead battery, or automatic turn off) it will remain in that state unless the pump is plugged in, the voltage drops to a level consistent with another state, or the pump is turned off, then on.

See Alarms in Section 3.5 for descriptions of low and dead battery.

4. Run

After setting infusion parameters, ***Run*** is pressed to begin fluid delivery. All necessary data must be entered (rate and volume to be infused), the Safety Clip must be in place, the cassette must be properly loaded, and the door must be closed or ***Run*** is disabled. If operating on battery, the battery voltage must be greater than 11.0 volts. If ***Run*** is pressed while the motor is backing off, the green run light will be solidly lit and the pump will not start running until the motor finishes backing off.

When the pump is running forward:

- the green run light is steadily lit
- the volume to be infused counts down in the display as volume is infused
- Primary is lit if pump is running a primary infusion, Secondary light is lit if running a secondary infusion, or neither is lit if running a Rate Taper infusion
- the Pumping Motion Display is lit to convey pumping action
- the Message Display shows the volume infused:

	`____mL this infusion`	or	`KVO ___mL this infusion`
or	`Taper ___mL this infusion`	or	`↓↑ ___mL this infusion`

- the ***Volume to be Infused*** and ***On/Off*** keys are disabled
- if Quick Rate Change is active, the 1(↓) and 3(↑) are active for changing the rate
- if ***Rate*** is pressed (Running Rate Change), the number keys are active
- if ***Options*** is pressed, the number keys and ⊡ will be active so that an option may be selected by its corresponding number. If no key is pressed within 10 seconds, the Message Display reverts to standard message.

During a ***non-insistent*** alarm, pressing ***Run*** or ***Silence*** silences the alarm without stopping fluid delivery; pressing ***Hold*** silences the alarm until the approximately 2.5 minute (6 minutes if door is open) "On Hold" alarm.

During an ***insistent*** alarm, pressing ***Hold*** or ***Silence*** silences the alarm for approximately 2.5 minutes (6 minutes if door open). Pressing ***Run*** silences the alarm and attempts to restart the pump. If the problem is not corrected the alarm will reoccur.

5. Hold

If ***Hold*** is pressed while the pump is running, the pump stops fluid delivery, the red hold light is steadily lit, and the Message Display shows the standard message.

During an ***insistent*** alarm, hold is automatically entered, and the red hold light flashes at a rate of 1 Hz at 50% duty cycle. The appropriate alarm message appears in the Message Display. The backlight flashes along with the audio alarm.

An ***insistent*** alarm may be silenced by pressing either ***Hold*** or ***Silence***.

If the pump is left on hold for more than 2.5 minutes (6 minutes if door is open), the ***insistent*** audio alarm sounds, the backlight and hold light flash, and the Message Display says:

```
On Hold
```

The On Hold timer (2.5 minutes if door closed, 6 minutes if door open) will be reset when any keys are pressed (except when the keypad is locked.)

6. Primary

Upon pump power up, the pump enters Primary (unless the pump was turned off in Rate Taper). Primary is indicated by the green primary light. When Primary is lit, the displays show the primary operating parameters.

To verify secondary infusion parameters while the pump is in primary, press ***Secondary***. The displays show the secondary rate and volume to be infused, and the Message Display shows the secondary volume infused. If the pump is running, the secondary parameters are displayed for 5 seconds, then they revert back to Primary.

7. Secondary

When the pump is operating in Secondary, the yellow secondary light is steadily lit, and the secondary parameters are displayed both in the numeric display (rate and volume to be infused) and the Message Display.

After a secondary infusion is complete, the pump sounds two repetition of the ***non-insistent*** alarm, then switches automatically to Primary.

To verify the primary infusion parameters while the pump is in secondary, press ***Primary***. The displays show the primary rate and volume to be infused, and the Message Display shows the primary volume infused. If the pump is running, the primary parameters are displayed for 5 seconds before reverting to secondary.

If a secondary infusion has been set up, and you attempt to start the pump in Primary, the following message is displayed for 5 seconds:

```
Secondary
was set
```

The pump sounds two repetitions of the ***non-insistent*** alarm, begins infusing the primary parameters, and the secondary volume to be infused is cleared. If running in secondary is desired after the message is displayed, press ***Hold***, then ***Secondary***, re-enter the secondary volume to be infused parameters (or press ***Volume to be Infused*** twice to recall previous setting), then press ***Run***.

Secondary delivery is not available during Rate Taper operation.

3.5 Alarms

The audio part of the alarm system consists of two piezo buzzers, one of which normally acts as a microphone to sense that the other is functioning properly. If the audio buzzer fails, the "microphone" buzzer sounds the audio alarm. (See audio alarm specifications.)

The Model 3000 & Micro 3100 use four types of audio alarm patterns; ***non-insistent***, ***insistent***, ***Back Up***, and a ***Continuous*** audio alarm. The ***non-insistent*** pattern (high/low chime) signals an alert condition during which the pump will continue to operate. The ***non-insistent*** alarm can be silenced by pressing ***Run***, ***Silence***, or ***Hold***. The ***insistent*** alarm pattern (high/high/low chime) signals a condition during which the pump will stop running and enter hold. During an ***insistent*** alarm condition, the pump will not run until the cause of the alarm is corrected. The ***Back Up*** audio alarm is a special high pitched alarm, and occurs if the audio alarm system fails. The ***Continuous*** alarm uses the same tone as the ***Back Up*** audio alarm, but with no pauses; it occurs to indicate an electromechanical system failure has occurred. Should a pump alarm with either the ***Back Up*** or ***Continuous*** tones, remove the pump from patient use and have it repaired by a qualified, 3M Infusion Therapy-trained technician.

Except where noted, when an alarm condition occurs, the red hold light illuminates and flashes at 1 Hz. The Message Display flashes with the alarm and an error or alarm message is displayed.

When the audio alarm is silenced, the hold light stops flashing and the Message Display remains lit with the alarm message displayed.

When a non-urgent alert condition occurs, such as KVO (infusion complete) and initial low battery, the ***non-insistent*** audio alarm is activated. In KVO, the green run light flashes at about 1 Hz with 50% duty cycle. In low battery, the yellow battery light flashes at about 1 Hz with 50% duty cycle. Pressing ***Run*** or ***Silence*** silences the audio alarm without stopping fluid delivery. Pressing ***Hold*** silences the audio alarm and stops fluid delivery.

If more than one alarm condition exists simultaneously, ***insistent*** alarms take precedence over ***non-insistent*** alarms.

The ***insistent*** audio alarm specification is:

Repetitions of high high low chime repeated every 2.25 seconds

Frequency of low is approximately 2200 Hertz
Frequency of high is approximately 2900 Hertz

The ***non-insistent*** audio alarm specification is:

Repetitions of high low chime repeated every 2.25 seconds

Frequency of low is approximately 2200 Hertz
Frequency of high is approximately 2900 Hertz

The ***Back Up*** audio alarm specification is:

Repetitions of high pitched tone repeated every 1.5 second

Frequency is approximately 3000 Hertz

The ***Continuous*** audio alarm specification is:

Same high pitched tone as ***Back Up*** alarm, without pause

NOTE
The *Back Up* and *Continuous* audio alarms are shrill, high pitched patterns, and are a clear indication that primary audio or the pump electromechanical system is not working properly. The pump must be removed from patient use immediately should either of these alarms occur.

3.6 Alert/Alarm Descriptions

Alerts:

1. KVO _____mL
this infusion

In Primary and Rate Taper modes, when the infusion is complete, the pump automatically switches to the KVO (Keep Vein Open) rate. In KVO, the ***non-insistent*** alarm sounds, the green run light flashes, the Pumping Indicator slows its flashing to the minimum rate, and the Message Display flashes and shows:

KVO _____mL
this infusion

(_____ indicates the volume infused since volume to be infused was programmed).

The pump continues running and the rate display shows the KVO rate (3.0 mL/h, unless the set rate is lower). Press ***Silence*** or ***Run*** to silence the audio alarm and continue running at the KVO rate for approximately 6 minutes.

If ***Hold*** is pressed, the pump stops and the audio alarm is silenced. The set rate reappears in the rate display, and the Message Display switches to standard message:

_____ mL
this infusion

(_____ shows the volume infused since volume to be infused was programmed).

2. Low battery
Plug in cord

NOT ADJUSTABLE

The Low Battery alert is triggered when the battery voltage falls between 11.0 and 11.6 volts DC. The battery light flashes, the ***non-insistent*** audio alarm sounds, and the following appears in the Message Display:

Low battery
Plug in cord

This alert condition does not stop fluid delivery.

The audio alarm can be silenced for up to 6 minutes by pressing ***Silence*** or ***Run*** without stopping fluid delivery, or by pressing ***Hold*** to stop fluid delivery. Silencing the alarm also returns the Message Display to its standard message, but the battery light continues flashing until the 6 minute period elapses again (unless the pump is plugged in during that time).

Plugging the pump in turns off the flashing battery light and cancels the low battery condition.

3. Rate change
not completed

The rate change not completed alert is triggered when Running Rate Change is attempted, but either not completed or completed improperly. The ***non-insistent*** audio alarm sounds, the Message Display flashes and shows the following:

Rate change
not completed

The pump continues to run at the original rate. Press ***Run*** or ***Silence*** to silence the audio alarm without stopping fluid delivery, and correctly perform the Running Rate Change procedure.

4. Secondary
was set

SECONDARY VTBI WILL GO TO ZERO WHEN THIS OCCURS

The secondary alert is activated if a secondary infusion is set up, but ***Run*** is pressed while the pump is in Primary. When ***Run*** is pressed, two repetitions of the ***non-insistent*** audio alarm sound, and the Message Display flashes and shows:

Secondary
was set

After 5 seconds, the Message Display switches to standard message, and primary delivery is continued. If secondary delivery is desired, press ***Hold***, press ***Secondary***, and reset secondary infusion. Press ***Run*** while pump is in Secondary.

Alarms:

5. Pump needs
service

The Models 3000 & Micro 3100 monitor specific internal conditions to detect system errors. The two microprocessors check each other and many of the system components, and shut down the pump with the ***Continuous*** or ***Back Up*** audio alarm should a malfunction be detected. Do not use the pump.

When a system error occurs, the pump must be sent to a technician for further inspection.

The error message in the Message Display for system error alarms is:

Pump needs
service

For a complete list of system errors/warnings, see Section 3.8.

6. System check
Turn off then on

In some cases, such as motor stall/interrupter when the motor is running forward, startup synchronization problem, or a warm boot (possibly caused by electrostatic discharge), an ***insistent*** or ***Back Up*** audio alarm sounds, and the display is:

```
System check
Turn off then on
```

If the condition is temporary, turning the pump off, then on will clear the alarm. If the condition persists, the pump will re-alarm.

7. Occlusion
below pump

If a downline (below pump) occlusion occurs (such as a closed lower roller clamp, pinched tubing, etc.), the pump stops fluid delivery, the hold light flashes, the ***insistent*** audio alarm sounds, and the Message Display backlight flashes with the following message appearing in the display:

```
Occlusion
below pump
```

Press ***Hold*** to silence the audio alarm. When the cause of the occlusion alarm is corrected, press ***Run***.

8. Air in cassette

CAN USE EMTY CASSETTE TO CHECK THIS ALARM

When the door is closed, the air detection system immediately begins scanning at the upper cassette chamber. If the cassette has been loaded in backwards (flat side in), or if air enters the line and reaches the upper cassette chamber, the pump stops fluid delivery (if running, the hold light flashes, the ***insistent*** audio alarm sounds, and the Message Display backlight flashes with the following message:

```
Air in cassette
```

Press ***Hold*** to silence the audio alarm. Correctly load the cassette, flat side out, or remove air from cassette. After the air is removed and the cassette is properly loaded, press ***Run***.

The pump generates emitter pulses for the air detect circuit at a rate of 1 per 20 motor pulses when infusing. (Pulse duration is 25 microseconds.) Three positives must be received before an air alarm is initiated.

9. No flow
above pump

Upon detection of an empty fluid container or occlusion above the pump, the pump stops fluid delivery, the hold light flashes, the ***insistent*** audio alarm sounds, and the Message Display backlight flashes with the following message:

```
No flow
above pump
```

The Models 3000 & Micro 3100 rely on gravity flow from the solution container to the pump for fluid delivery. With each rotation of the cams, the microprocessor looks for a signal which results from the presence of sufficient fluid pressure from above the pump. If the pressure is not there, an alarm is generated.

Press ***Hold*** to silence the audio alarm. When the cause of the alarm is removed, press ***Run***.

10. Door open

If the door is opened while the pump is running, the pump stops fluid delivery, the hold light flashes, the ***insistent*** audio alarm sounds, and the Message Display backlight flashes with the following message:

```
Door open
```

NOTE
If the door is open, *On/Off* and *Run* key are disabled.

Press ***Hold*** before opening the door.

11. On Hold

This alarm is generated if the pump is left turned on and on hold with the door closed for more than 2.5 minutes, or left turned on and on hold with the door open for more than 6 minutes.

When this alarm occurs, the ***insistent*** audio alarm sounds, the hold light flashes, and the Message Display backlight flashes with the following message:

```
On Hold
```

Press ***Hold*** or ***Silence*** to silence the audio alarm. Set up pump for use and then press ***Run***, or turn pump off.

12. Battery too low
Plug in cord

If the pump is not plugged in following the initial low battery alarm, it will continue to run, alarming every 6

minutes, until a dead battery signal is initiated when the voltage is less than 11.0 volts DC. If the pump reaches 11.0 volts or lower, it stops running, activates the ***insistent*** audio alarm, flashes the hold light, and displays the following:

```
Battery too low
Plug in cord
```

Press ***Hold*** or ***Silence*** to silence the alarm. The pump will not run until it is plugged in. If the pump is left alarming, it will shut off, and remain off until the power cord is plugged in, if battery voltage falls below 10.0 volts to prevent deep battery discharge (see page 3-10, Automatic Power Down).

13. `Close clamp!`
`Load Safety Clip`

Failure to properly load the Safety Clip during cassette loading will result in this alarm when the door is closed. The ***insistent*** audio alarm sounds, the red hold light flashes, and the Message Display flashes with the following message:

```
Close clamp!
Load Safety Clip
```

Press ***Silence*** or ***Hold***, close the lower roller clamp, and correctly load the Safety Clip.

14. `Loading problem`
`Check tubing set`

If the pressure plate position switch is not activated when the door latch is closed, the pump will not operate. This indicates that the cassette or tubing is not properly positioned (or that the motor has stalled in reverse). The ***insistent*** audio alarm sounds, the hold light flashes, and the Message Display flashes with the following:

```
Loading problem
Check tubing set
```

Press ***Hold*** or ***Silence*** and properly load the cassette. The cassette must be loaded flat side out, with the three cassette chambers positioned inward over the pistons, and any upper tubing clamp is open.

Several other messages (displayed without an accompanying audio alarm) are associated with the Optional Functions of the Model 3000 and Micro 3100 Infusion Pumps, and are described and explained in that section of this manual.

Table 3-1 Summary of Alarm Conditions

Reference Troubleshooting Guide in Section 5 for complete alarm troubleshooting procedures.

Message Screen/ Indicator	Audio Tone	Pump Response/To Silence Alarm & Correct
Pump needs service	***Insistent*** or ***Continuous***	Pump stops (if running) and cycles to hold. Indicates an electrical and/or mechanical problem. Turn pump off. Do not use pump; needs repair by a 3M Infusion Therapy trained technician.
System check Turn off then on	***Insistent***	Pump stops (if running) and cycles to hold. Indicates a potential problem with pump. Turn pump off, then back on. If alarm persists, remove pump from use and have it repaired by a 3M Infusion Therapy trained technician.
Close clamp! Load Safety Clip	***Insistent***	Pump cycles to hold. Indicates Safety Clip not correctly loaded. Press ***Silence*** or ***Hold,*** close lower roller clamp, and correctly load safety clip.
Loading problem Check tubing set	***Insistent***	Pump cycles to hold. Indicates problem detected as door is being closed (cassette not properly loaded, tubing out of place, etc.). Press ***Silence*** or ***Hold.*** Correctly load cassette and tubing before closing door.
On Hold	***Insistent***	Pump left on hold for 2 1/2 minutes with door closed, or 6 minutes with door open. Press ***Silence*** or ***Hold*** to quiet audio alarm. Press ***Run*** if ready to begin infusion, or turn pump off if not in use.
Air in cassette	***Insistent***	Pump stops and cycles to hold. Indicates air detected in upper cassette chamber. Press ***Silence*** or ***Hold*** and remove air (close lower roller clamp; open door; wait for cassette to fill; slowly close door; repeat if necessary).
No flow above pump	***Insistent***	Pump stops and cycles to hold. Indicates insufficient flow from container to pump. Press ***Silence*** or ***Hold*** and check upper line for: • Empty container. If desired, replace container. • Insufficient head height provided. Raise container height so drip chamber is 6-12 inches above top of pump. • Closed upper tubing clamp. Open upper clamp. • Vent filter is wet, spike is damaged, or other set problem. Replace administration set.
Occlusion below pump	***Insistent***	Pump stops and cycles to hold. Indicates pressure below pump exceeds Occlusion Alarm Setting. Press ***Silence*** or ***Hold,*** and open lower tubing clamp, or eliminate any lower tubing restrictions. Change Occlusion Alarm Setting, if not appropriate for infusion. Verify patient catheter is patent.
WARNING **The occlusion detection sensor is designed to detect backpressure in the administration set, but is not designed to detect infiltration. In accordance with institution's policies and procedures, operator must periodically inspect patient's infusion site for swelling, temperature changes, and/or other signs of infiltration.**		
Door open	***Insistent***	Pump stops and cycles to hold. Indicates door opened while pump was running. Press ***Silence*** or ***Hold.*** Press ***Hold*** before opening door.
Rate change not completed	***Non-Insistent***	Pump continues to run at set rate. Indicates a Running Rate Change was attempted, but not properly completed. Press ***Silence*** or ***Run*** to quiet audio alarm, and re-enter Running Rate Change.
Secondary was set	***Non-Insistent***	Two repetitions of ***non-insistent*** audio alarm sound, and pump begins delivery of Primary infusion settings. Reset Secondary parameters, if desired, and press ***Run*** while Secondary is selected.
KVO ____mL this infusion	***Non-Insistent***	Pump begins delivery at KVO rate. Indicates infusion complete. Press ***Silence*** or ***Run*** to continue KVO delivery without alarm (pump realarms every 6 minutes) - or - Press ***Hold*** and program new infusion, or remove set and turn pump off if finished.

Table 3-1 Summary of Alarm Conditions - Continued

Reference Troubleshooting Guide in Section 5 for complete alarm troubleshooting procedures.

Message Screen/ Indicator	Audio Tone	Pump Response/To Silence Alarm & Correct
Low battery Plug in cord	***Non-Insistent***	Pump continues to operate at selected rate. Indicates 1/2 hour or less of battery power remains. Press ***Silence*** or ***Run*** to quiet audio alarm for 6 minutes; plug pump in (if possible).
Battery too low Plug in cord	***Insistent***	Pump stops (if running) and cycles to hold. Indicates battery is depleted. Press ***Silence*** or ***Hold*** to quiet audio alarm. AC power cord must be plugged in to continue infusion.
Messages Without Audio Alarm:		
Keypad locked		Keypad Lockout button on rear of pump has been pressed. To use keypad, unlock by pressing Keypad Lockout Button.
↓↑ ____mL this infusion		Quick Rate Change has been selected.
Must exit ↓↑ to use Taper		Quick Rate Change selected; Rate Taper cannot be used at same time.
Taper ____ml this infusion		Rate Taper has been selected.
Must exit Taper to use ↓↑		Rate Taper selected; Quick Rate Change cannot be used at same time.
Cannot infuse * To review		Rate Taper program cannot be infused as entered. Change Rate Taper variables.

3.7 Options

There are six menu options available by pressing ***Options***. With the exception of Battery Test, these options can be used while the pump is running.

1 Standard Message
2 Time Remaining
3 Message Display Light
4 Battery Test
5 Quick Rate Change
6 Rate Taper

Press ***Options*** repeatedly to advance you through the options menu, or, jump directly to the desired option by pressing ***Options*** and then the number key assigned to that option (shown above).

NOTE
When the pump is operating in Rate Taper mode, Quick Rate Change is not available, and vice-versa.

1. Standard Message

Standard message refers to the pump's normally displayed message when no option is selected. The volume infused is displayed as follows:

```
_____ mL
this infusion
```

It applies to either Primary or Secondary, whichever is running. When Secondary is complete, the standard message will switch to Primary and start incrementing the primary volume 'this infusion'.

To check the volume infused in secondary after the pump has switched to primary, press ***Secondary*** once. For 5 seconds, the Message Display will display the volume infused during secondary delivery.

This value is saved until a new volume to be infused is entered. The accumulated volume infused since last cleared can be viewed by pressing ***Total Volume*** (see section 3.3).

2. Time Remaining Display Optional Function

This option displays time remaining, in hours and minutes, until completion of the present infusion. To use time remaining display, press ***Options***, then ***2***, or press ***Options*** until:

```
__ hrs __ mins
remaining
```

appears in the Message Display. This applies to both Primary and Secondary. The time is calculated from the rate and volume to be infused. In Rate Taper mode, the time is calculated from taper rate and taper volume to be infused parameters.

3. Message Display Light Optional Function

The Message Display light normally turns off 1 minute after the pump begins running (or if left on hold while using battery power). This option allows you to keep the message light on constantly. To keep the light on, press ***Options***, then ***3***, or press ***Options*** until

```
To keep light
on press *
```

appears in the Message Display. Press [*]. The backlight will remain on constantly and, if an alarm situation arises, it flashes. To turn off the panel light, reenter the Message Display Light option, which will read:

```
To turn light
off press *
```

Press [*], and the pump reverts to normal backlight operation.

NOTE
Once the pump is turned off, the backlight setting will revert back to normal operation. When the pump is turned back on, you must reselect Option 3.

NOTE
The backlight has a finite life, and will, if used constantly, cause the light to dim and eventually will lead to Message Display replacement. 3M recommends that this option not be kept on for extended periods of time.

Refer to Section 3.3, item 1 for more information on the backlight function.

4. Battery Test Optional Function

With the pump on hold and on battery power, the approximate battery capacity may be determined using this option. To use this option, press ***Options***, then ***4***, or press ***Options*** until

```
Battery Test
Press * to begin
```

appears in the Message Display. When [*] is pressed, the pump turns on all LED's and the rate and volume to be infused displays (0s) to form a known battery load, then internally measures battery voltage. A message appears in the Message Display such as:

```
++++++++++++++
LOW battery FULL
```

A full row of pluses indicates a fully charged battery, and one plus indicates an almost dead battery. Each + indicates increasing battery voltage, based on the following table:

```
11.1  +
11.2  +
11.3  ++
11.4  +++
11.5  ++++
11.6  +++++
11.7  ++++++
11.8  ++++++++
11.9  +++++++++
12.0  +++++++++
12.1  ++++++++++++
12.2  ++++++++++++++++
```

NOTE
It is possible to get a false reading if the battery is in poor condition and was recently charged.

If this option is selected while the power cord is plugged in, the following message appears:

```
Battery Test
Unplug then test
```

indicating that the power cord must be unplugged before the test can proceed.

If this option is selected while the pump is running on battery power, the following message will appear:

```
Battery Test
only on Hold
```

indicating that the battery can only be tested while the pump is on hold.

If the pump is on hold, then either message will remain in the display for 2.5 minutes, until the On Hold alarm occurs, or until some other programming action is initiated.

5. Quick Rate Change Optional Function

This option allows changes of flow rate with single presses of the keypad while the pump is running. Quick Rate Change may be selected while the pump is running, or while on hold. To select Quick Rate Change, press ***Options***, then ***5***, or press ***Options*** until

```
↓↑  Rate Change
Press * to begin
```

appears in the Message Display. Press [*], and the Message Display shows instructions for quick rate change as follows:

```
Press 1 to ↓
  Press 3 to ↑
```

NOTE
The Message Display reverts to the standard message after 10 seconds if no additional keys are pressed.

Each press of the ***1*** (↓) key decreases the entered rate by 1 mL/h (or 0.1 mL/h if the original rate contains a decimal point). Each press of the ***3*** (↑) key increases the entered rate by 1 mL/h (or 0.1 mL/h if the original rate contains a decimal point).

You can only use the Quick Rate Change in Primary or Secondary, whichever is running. For example, if the pump is operating in Primary and you press Secondary, the ***1*** (↓) and ***3*** (↑) keys are inactive until the display returns to Primary.

The pump remains in Quick Rate Change mode until you exit the option. The Quick Rate Change standard message is:

```
↓↑ ___ mL
this infusion
```

To exit Quick Rate Change, press ***Options*** until the following message appears:

```
Exit ↓↑ Rate?
Press * to exit
```

Press [*] to exit Quick Rate Change. The standard message returns. Quick Rate Change is automatically exited when the pump is turned off.

6. Rate Taper Optional Function

This Optional Function allows automatic tapering of the infusion rate up or down for administration of Total Parenteral Nutrition (TPN), Total Nutrient Admixture (TNA or Three-In-One), or other applicable therapies.

Rate Taper is programmed by setting four infusion variables. The pump makes the necessary calculations, and performs the required rate changes at the correct times. A Rate Taper infusion can be repeated exactly as the previous infusion, or changes can easily be made if volume or time requirements vary from one infusion to another.

The diagram on the following page shows a typical Rate Taper infusion and the four variables set by the operator:

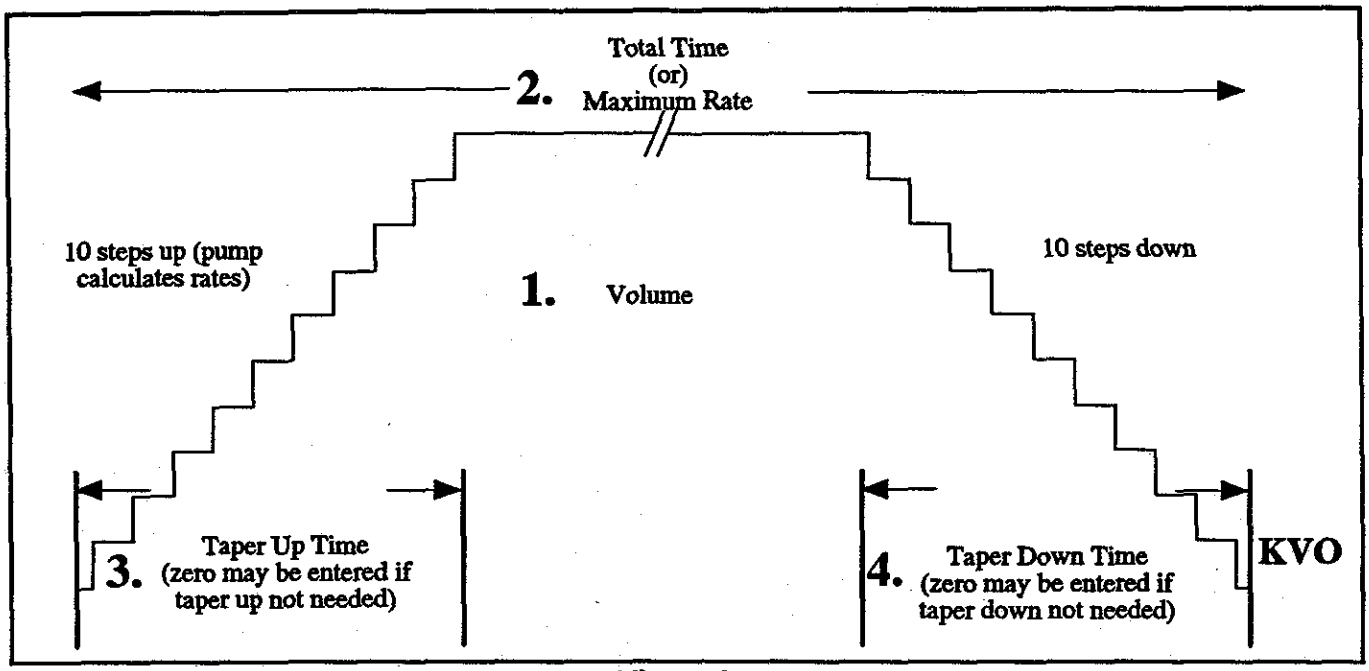
Total Time
(or)
Maximum Rate
2.
10 steps up (pump calculates rates)
1. Volume
10 steps down
3. Taper Up Time (zero may be entered if taper up not needed)
4. Taper Down Time (zero may be entered if taper down not needed)
KVO

Figure 3-4
Rate Taper Program Variables

The Rate Taper optional function may be programmed by Total Time or Maximum Rate:

Rate Taper Method	1. Total Time	2. Maximum Rate
Advantages:	Allows selection of exact Total Time for Rate Taper delivery.	Allows selection of exact Maximum Rate pump will run for appropriate Rate Taper delivery over shortest time possible.
Operator Enters:	1. Volume to be Infused 2. Total Time for infusion. 3. Time to taper rate up. 4. Time to taper rate down.	1. Volume to be Infused. 2. Maximum Rate of infusion. 3. Time to taper rate up. 4. Time to taper rate down.
Pump Calculates and Displays:	- Maximum rate of infusion. - 10 Rate steps for tapering up and down.	- Total time for infusion. - 10 Rate steps for tapering up and down.

NOTE
The highest allowable infusion rate in Rate Taper is 400 mL/h (99.9 mL/h on Micro 3100).

NOTE
Rates less than 1 mL/h will always be displayed in 10ths. Pump may calculate and run rates to nearest 10ths mL/h even if not programmed in 10ths. In that case, the displayed rate is rounded to the nearest 1 mL/h (even if it exceeds 1 mL/h).

To Use Rate Taper:

With pump on hold, press ***Options***, then ***6***, or press ***Options*** until

```
Rate Taper
Press * to set
```

appears in display. Press ⊛, and follow instructions below for programming Rate Taper by Total Time or Maximum Volume. Note that neither the Primary nor Secondary indicator is lit while Rate Taper option is selected.

To Program Rate Taper by Total Time

(example follows these instructions)

When Message Display is:

```
Rate Taper
Press * to set
```

Press ⊛ and display is:

```
Volume ____mL
Press * when set
```

Previous volume setting is flashing. Enter volume to be infused (if different than flashing volume). If an error is

made while entering volume, press ***Volume to be Infused*** and re-enter correct setting. Press [*] when desired volume is displayed. Message display is:

```
1 For total time
  2 For max rate
```

Press *1* and display is:

```
Total   __h __m
Press * when set
```

Enter time, in hours and minutes, to complete infusion. For Total Time less than 10 hours, enter "0" before the hours digit. For example, 09 h, 00 min. If an error is made while entering a time value, press any number key until furthest left (first hours digit) is flashing, then enter correct time value.

Press [*] and display is:

```
Taper up _h __m
Press * when set
```

Enter time, in hours and minutes, for tapering up at beginning of infusion (zero hours and minutes may be entered if taper up is not desired).

Then press [*] and display is:

```
Tpr down  _h __m
Press * when set
```

Enter time, in hours and minutes, for tapering down at the end of the infusion (zero hours and minutes may be entered if taper down is not desired).

Then press [*] and display is:

```
Maximum_____ mL/h
* To continue
```

Pump has calculated Maximum Rate required to complete Rate Taper infusion within time period specified. Verify rate is appropriate for patient.

If not appropriate, press [*] twice and adjust program (longer total time may be required).

If maximum rate is appropriate for patient, press [*] and display is:

```
RUN to infuse
* Resets Taper
```

If ready to begin Rate Taper delivery, press ***Run***. Infusion begins and display counts up volume infused starting from:

```
Taper        0 mL
this infusion
```

If display is

```
RUN to infuse
* Resets Taper
```

and it is necessary to review or make changes to Rate Taper program, press [*] and display repeats programming sequence beginning with

```
Volume _______mL
Press * when set
```

NOTE
If [*] is pressed when display is `RUN to infuse/* Resets Taper`**, all previous taper program settings may be re-entered, from the beginning, for review or program changes.**

Example of Rate Taper by Total Volume Infusion:

To deliver:
1500 mL over 9 hours and 30 minutes; tapering up for 1 hour; tapering down for 45 minutes.

Press ***Options***, then *6*.

Screen Prompt:	User Enters:
`Rate Taper` `Press * to set`	Press [*].
`Volume _____mL` `Press * when set`	Enter 1500, then press [*].
`1 For Total Time` `  2 For max rate`	Press *1*.
`Total __h __m` `Press * when set`	Enter 09 hours, 30 minutes. Press [*].
`Taper up _h __m` `Press * when set`	Enter 1 hour, 00 minutes. Press [*].
`Tpr down _h __m` `Press * when set`	Enter 0 hours, 45 minutes. Press [*].
`Maximum 173 mL/h` `* To continue`	appears in display. Pump will taper to 173 mL/h maximum. Press [*].
`RUN to infuse` `* Resets Taper`	Press ***Run***. First step (17 mL/h) appears in Rate Display, and Message

Display begins counting up volume infused.

To Program Rate Taper by Maximum Rate

(example follows these instructions)

When Message Display is:

```
Rate Taper
Press * to set
```

Press ✱ and display is:

```
Volume ____mL
Press * when set
```

Previous volume setting is flashing. Enter volume to be infused (if different than flashing volume). If an error is made while entering volume, press ***Volume to be Infused*** and re-enter correct setting. When desired volume is displayed, press ✱; display is:

```
1 For total time
  2 For max rate
```

Press *2* and display is:

```
Maximum ____mL/h
Press * when set
```

Enter maximum rate at which infusion should run. If an error is made while entering the maximum rate, press ***Rate*** and re-enter correct setting. When desired maximum rate is displayed, press ✱ and display is:

```
Taper up __h __m
Press * when set
```

Enter time, in hours and minutes, for tapering up at the beginning of the infusion (zero hours and minutes may be entered if taper up is not desired). Then press ✱ and display is:

```
Tpr down __h __m
Press * when set
```

Enter time, in hours and minutes, for tapering down at the end of the infusion (zero hours and minutes may be entered if taper down is not desired). Then press ✱ and display is:

```
Total    __h __m
* To continue
```

Pump has calculated length of time, in hours and minutes, required to complete infusion with maximum rate entered. Verify time is appropriate for patient.

If not appropriate, press ✱ twice and adjust program (higher or lower maximum rate may be required).

If total time is appropriate, press ✱ and display is:

```
RUN to infuse
* Resets Taper
```

If ready to begin Rate Taper delivery, press ***Run***. Rate Taper infusion begins and display counts up volume infused beginning with

```
Taper        0 mL
this infusion
```

When display is

```
RUN to infuse
* Resets Taper
```

and it is necessary to review or make changes to Rate Taper program, press ✱ and display repeats programming sequence beginning with:

```
Volume ____mL
Press * when set
```

NOTE

If ✱ is pressed when display is `RUN to infuse/* Resets Taper`, all previous program settings may be re-entered, from the beginning, for review or program changes.

Example of Rate Taper by Maximum Rate Infusion:

To deliver:
1950 mL at a maximum rate of 225 mL/h; tapering up for 1 hour and 30 minutes; tapering down for 30 minutes.

Press ***Options***, then *6*.

Screen Prompt:	User Enters:
`Rate Taper` `Press * to set`	Press ✱.
`Volume ____mL` `Press * when set`	Enter 1950, then press ✱.
`1 For Total Time` `  2 For max rate`	Press 2.
`Maximum __mL/h` `Press * when set`	Enter 225 mL/h. Press ✱.
`Taper up _h __m` `Press * when set`	Enter 1 hour, 30 minutes. 30 minutes. Press ✱.

`Tpr down _h __m` `Press * when set`	Enter 0 hours, 30 minutes. Press ✱.
`Total 09h 40m` `* To continue`	appears in display. Pump will complete infusion in 9 hours and 40 minutes. Press ✱.
`RUN to infuse` `* Resets Taper`	Press ***Run***. First step (23 mL/h) appears in Rate Display, and Message display begins counting up volume infused.

Rate Taper Programs the Pump Cannot Infuse

If values are entered which result in a Rate Taper program that cannot be infused, pump will not start when ***Run*** is pressed. (For example, if volume and time values are entered which require a flow rate greater than 400 mL/h.) Message Display is:

```
Cannot infuse
* To review
```

Press ✱ to repeat Rate Taper programming sequence beginning with

```
Volume ____mL
Press * when set
```

An adjustment is required in volume, time, or maximum rate values.

Rate Taper End Early Feature

If it is necessary for a patient's infusion to end earlier than planned, this feature provides an alternative to stopping abruptly while infusing at a significantly high flow rate. Using this feature will result in delivery of less than the full volume to be infused which was programmed.

After a Rate Taper infusion has begun, press ***Options***; Message Display is

```
End early ____min
Press * when set
```

Display will show actual time remaining or 30 minutes, whichever is less. If displayed time is an acceptable length for infusion rate to taper down, press ✱. (Any number of minutes from 1 to 99 may be entered if not acceptable.) Display is

```
RUN to end early
* to continue
```

Press ***Run*** to begin tapering down immediately. When rate has tapered down over length of time selected, pump alarms and continues delivery at the KVO rate.

If you do not wish to end early, press ✱ to continue Rate Taper infusion as originally programmed. If pump is on hold, press ***Run*** to continue infusing.

Pre-Programming Rate Taper for Later Use

If pump is being pre-programmed for later use it may be turned off immediately after programming when Message Display is:

```
RUN to infuse
* Resets Taper
```

When pump is next turned on, it is ready to begin Rate Taper infusion which was programmed before being turned off. When pump is on, display is

```
RUN to infuse
* Resets Taper
```

Resuming, Restarting, or Reprogramming Rate Taper

If the pump is turned off when Rate Taper optional function is selected, current Rate Taper program is stored in memory.

If taper program was set but not run, when pump is next turned on display is

```
RUN to infuse
* Resets Taper
```

When a previous Rate Taper program has been partially or fully completed, and pump is on hold, display is

```
Taper ____mL
this infusion
```

To resume a partially completed Rate Taper, press ***Run***.

NOTE
If ✱ is pressed when display is `RUN to infuse/* Resets Taper`**, all previous taper program settings may be re-entered, from the beginning, for review or program changes.**

To repeat a Rate Taper program exactly as run previously, from its beginning, press ***Volume to be Infused*** twice. Press ***Run*** to begin infusing.

To repeat a Rate Taper program, but substitute a different volume than previously infused, press ***Volume to be***

Infused, then enter volume for next infusion. Note that this will change Total Time and/or Maximum Rate. Verify correct volume is displayed, then press ***Run*** to begin infusing.

If different values must be programmed for Total Time, Maximum Rate, Taper up time, or Taper down time, press ***Options*** until display is

```
RUN to infuse
* Resets Taper
```

Press [*] and display repeats programming sequence beginning with

```
Volume     ____ mL
Press * when set
```

To Exit Rate Taper Option

To exit Rate Taper and return to standard pump operation, press ***Hold***, then ***Options*** repeatedly until Message Display is

```
Exit Rate Taper?
Press * to exit
```

Press [*] to return to standard pump operation. Display is:

```
____ mL
this infusion
```

NOTE
It may take up to 9 presses of *Options* to exit Rate Taper.

3.8 Biomedical Special Functions

The Biomedical Special Functions are designed for use by hospital biomedical engineering departments and 3M Infusion Therapy Service. These functions and tests are entered by simultaneously pressing ***Options*** and ***On/Off*** when the pump is off, and entering the appropriate security codes. The ID that must be entered is *3031*. The password that must be entered is *7867*. You can advance through the special functions by pressing ***Options***. The special functions and tests are:

- System Warning and Error Code Display (if present)
- Snapshot
  - Screen-a
  - Screen-b
- Time and Date Display
- Pump History Display
- Charge History Display
- Pressure (Calibrate Mode) Display
- Select Baud Rate
- Select Language
- Display Battery Use
- Display Model Number and Software Versions.
- Audio Alarm Test

1. System Warning and Error Code Display

If an error occurs while the pump is operating, it is recorded in a snapshot, an audio alarm sounds, and the message

```
System check
Turn off then on
```

appears in the Message Display. If the system error resulted from a temporary condition, turning the pump off then on will clear the alarm and allow you to continue the infusion. If the error condition still exists, the alarm will recur.

The error code can be viewed in the Message Display at a later time by entering the biomedical special functions screen as described above. When special functions is entered, the pump defaults to the screen displaying the error code. The error is cleared upon exit from special functions but will be stored as a snapshot event.

If an error has not occurred, then pressing ***Options***, ***On/Off***, and entry of security codes takes you right into the snapshot screens.

System errors are displayed as:

```
System error
Service code XX
```

System warnings are displayed as:

```
System warning
Service code XX
```

The system warnings and errors are:

Code	Error/Warning
01	Power Fail (Battery) Detected
02	Motor Monitor Communication timeout error
03	Motor Monitor RAM error
09	Motor Monitor Watchdog error
10	CPU1 ROM Checksum error
11	Motor Monitor Checksum error
12	CPU1 RAM failure
13	NV RAM checksum mismatch
14	Main audio alarm Failure
15	Motor fast error detected by Motor Monitor
16	Motor slow error detected by Motor Monitor
17	Motor disable test failure
19	Air detect test failure
20	No flow above pump circuit error

21	Display board communications error
22	Display digit error, 0-9
23	Display LED error, 0-6
24	Display Board ROM error
25	Display Board RAM error
28	Motor stall/interrupter
29	Pressure Search Limit corrupted in NV RAM
30	Warm Boot
31	Micro/Macro discrepancy error
32	Pressure Plate Position Switch change during RUN
33	Rate Calibration Factor Corrupted in NVRAM
34	LCD Display Failure
35	Undefined Interrupt occurred
36	Display field overflow error
37	Display field parameter error
38	Non-volatile RAM battery low
39	Stack overflow
40	Pressure Plate Position Switch =1 when door is open
41	Pressure > 1 psi when door is open
42	Safety clip in place when door is open

Errors 29, 31, and 33 are system errors; all others are system warnings.

2. Snapshot Screen-a

The snapshot display appears as follows:

```
## MMDD HRmm ZZ
RATE VTOBI VOLUM
```

ranges from 1 to 50 and represents the snapshot event with the most recent event numbered 1.

While in the screen, if [*] is pressed, snapshot event screen-b will be displayed. The *1* (↓) or *3* (↑) keys advance to the previous or next snapshot event, respectively. Snapshot events will be displayed from number 1 through number 50. Pressing *1* (↓) when event 1 is displayed will result in event 50 being displayed. Pressing *3* (↑) when event 50 is displayed will result in event 1 being displayed.

MM ranges from 1 to 12 and represents the month,
DD ranges from 1 to 31 and represents the day,
HR ranges from 0 to 23 and represents the hour (Greenwich Mean Time - GMT),
mm ranges from 0 to 59 and represents the minute (GMT),
ZZ ranges from 0 to 99 and represents the system/state code.

RATE ranges from 0 to 999 mL/h (0.1 to 99.9 mL/h on Model 3100) and represents the rate of the current mode (primary or secondary) at the time of the snapshot. Note that there is an implied decimal point, i.e. the value displayed in the right most digit is in 1/10th mL.

VTOBI ranges from 0 to 9999mL (0.1 to 999.9 mL on Model 3100) and represents the volume to be infused of the current mode at the time of the snapshot. Note that there is an implied decimal point, i.e. the value displayed in the right most digit is in 1/10th mL.

VOLUM ranges from 0 to 9999 mL and represents total volume infused this infusion. Note that there is an implied decimal point, i.e. the value displayed in the right most digit is in 1/10th mL.

The following list is a definition of the codes which are displayed in the ZZ section of the screen:

Code	Action
00	No action, initialization value
01	Power Fail (Battery) Detected
02	Motor Monitor Communication timeout error
03	Motor Monitor RAM error
09	Motor Monitor Watchdog error
10	CPU1 ROM Checksum error
11	Motor Monitor Checksum error
12	CPU1 RAM failure
13	NV RAM checksum mismatch
14	Main audio alarm Failure
15	Motor fast error detected by Motor Monitor
16	Motor slow error detected by Motor Monitor
17	Motor disable test failure
19	Air detect test failure
20	No flow above pump circuit error
21	Display board communications error
22	Display digit error, 0-9
23	Display LED error, 0-6
24	Display Board ROM error
25	Display Board RAM error
28	Motor stall/interrupter
29	Pressure Search Limit corrupted in NV RAM
30	Warm Boot
31	Micro/Macro discrepancy error
32	Pressure Plate Position Switch change during RUN
33	Rate Calibration Factor Corrupted in NVRAM
34	LCD Display Failure
35	Undefined Interrupt occurred
36	Display field overflow error
37	Display field parameter error
38	Non-volatile RAM battery low
39	Stack overflow
40	Pressure Plate Position Switch =1 when door is open
41	Pressure > 1 psi when door is open
42	Safety clip in place when door is open
64	On HOLD Alarm
65	Stop pumping - Occlusion
66	Stop pumping - Air
67	Stop pumping - No flow above pump
68	Stop pumping - Door Open

Reinitial (2nd

69	Stop pumping - Loading problem, Pressure Plate
70	Status of pump - Low Battery (11.0 <= voltage < 11.6)
71	Stop pumping - Dead Battery (voltage < 11.0 volts)
72	Stop pumping - Safety Clip
73	Change rate to KVO
74	Running rate change not completed
75	On battery (loss of main power)
76	Start pumping using RUN key
77	Stop pumping using HOLD key
78	Secondary to primary switch
79	Occlusion Alarm Setting change to low
80	Occlusion Alarm Setting change to medium
81	Occlusion Alarm Setting change to high
82	Running rate change
83	↓↑ rate change
84	Taper to new rate
85	Power down
86	Pump on Battery
87	Turn off AC
88	Turn on AC
89	Motor reverse stall
90	Power change - battery to AC

3. Snapshot Screen-b

The snapshot display will appear as follows:

```
##  AAA BBB CCC
DDD EEE FFF GGG
```

ranges from 1 to 50 and represents the snapshot event with the most recent event numbered 1.

If ★ is pressed, snapshot event screen-a will be displayed. The *1* (↓) or *3* (↑) keys will advance to the previous or next snapshot event, respectively. Snapshot events will be displayed from number 1 through number 50. Pressing *1* (↓) when event 1 is displayed will result in event 50 being shown. Pressing *3* (↑) when event 50 is displayed will result in event 1 being displayed.

AAA - Is the decimal (0-255) representation of the conditions in the pump's main modes. The decimal number must be converted to binary; Chart A is then used for interpretation.

BBB - Is the decimal (0-255) representation of the conditions in the pump's state modes. The decimal number must be converted to binary; Chart B is then used for interpretation.

CCC - Is the decimal (0-255) representation of the conditions found in the pump's physical modes. The decimal number must be converted to binary; Chart C is then used for interpretation.

DDD - Is the decimal (0-255) representation of the conditions found in the pump's sensor flags. The decimal number must be converted to binary; Chart D is then used for interpretation.

EEE - Is the keypad state input mode as follows:

0	Keypad default mode
1	Occlusion Alarm Setting
2	Options digit shortcut
3	Options
4	Quick rate change
5	Total Volume
6	Taper end early
7	Taper setup
8	Keypad locked
9	Rate input
10	Volume to be infused input
11	Taper Run

FFF - Is the average of the last two analog-to-digital readings of the battery voltage at the time the snapshot was generated and ranges from 0 to 255. Voltage can be found in the look-up chart below.

A to D Value	Voltage
186	11.1
190	11.3
191	11.4
193	11.5
195	11.6
197	11.7
199	11.8
200	11.9
202	12.0
204	12.1
205	12.2

A to D values that fall between those listed may be interpolated to determine the voltage.

Example:
If the A to D value is 194, the voltage value is 11.55.

GGG - Is the average of the last 2 analog-to-digital readings of the pressure sensor, and ranges from 0 to 255. If the system state code on screen-a is an undefined interrupt (35), this value is the interrupt identifier as follows:

GGG	Interrupt Identifier
0	Reset
1	Clock monitor
2	Cop watchdog
3	Bad opcode
4	Software interrupt (SWI)
5	Non-maskable interrupt (XIRQ)
6	Hardware interrupt (IRQ)

Chart A

	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0
0 =	Not used	Not used	Unit is not in Quick Rate Change	Unit is not in dead battery condition	Unit is not in low battery condition	Unit is not in KVO	Unit is in Primary	Unit is not in Run
1 =	Not used	Not used	Unit is in Quick Rate Change	Unit is in dead battery condition	Unit is in low battery condition	Unit is in KVO	Unit is in Secondary	Unit is in Run

Chart B

	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0
0 =	Primary or Secondary rate or volume has not been decimal since total volume was last cleared	Secondary VTBI value does not have a decimal place	Secondary rate value doesn not have a decimal place	Primary VTBI Value has a decimal place	Primary rate value does not have a decimal place	The standard message is not in the Message Display	Unit is not in Rate Taper End Early mode	Unit is not in Rate Taper
1 =	Primary or Secondary rate or volume has been decimal since total volume was last cleared	Secondary VTBI value has a decimal place	Secondary rate value has a decimal place	Primary VTBI value does not have a decimal place	Primary rate value has a decimal place	The standard message is in the Message Display	Unit is in Rate Taper End Early mode	Unit is in Rate Taper

Chart C

	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0
0 =	Not used	Run mode is not pending	Not used	Cassette is not in position	Not used	Safety Clip not in place	Door is not open	Unit has not been turned on
1 =	Not used	Run mode is pending	Not used	Cassette is in position	Not used	Safety Clip in place	Door is open	Unit has been turned on

Chart D

	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0
0 =	Micro mode jumper is in place	On/Off key sensor reads not pressed	Not used	Not used	Auxiliary power is on	CTS not active	Keypad is not locked out	Unit is on AC
1 =	Micro mode jumper is not in place	Not used	Not used	Not used	Auxiliary power is off	CTS active	Keypad is locked out	Unit is on battery

7	Real time interrupt
8	Timer input capture 1
9	Timer input capture 2
10	Timer input capture 3
11	Timer output compare 1
12	Timer output compare 2
13	Timer output compare 3
14	Timer output compare 4
15	Timer output compare 5
16	Timer overflow
17	Pulse accumulator overflow
18	Pulse accumulator input edge
19	Serial Peripheral Interface
20	Serial Communications Interface

GGG - Is the average of the last two analog-to-digital readings of the pressure sensor and ranges from 0 to 255. This number can be used to determine the pumping pressure at the time the snapshot was generated.

The pressure sensor has a zero offset A to D value of 0 to 3. In addition to that, every increment of 21 represents 1 psi of pressure. Therefore, to compute the pumping pressure from the value in GGG, subtract 5 and divide the remainder by 21 [(GGG - 5)/21].

Example:
If the A to D value found in GGG is 131, the conversion to psi is (131-5)/21 = 6 psi.

Use of Snapshot Screens

To use the information in the snapshot screens, record the numbers from screen A and screen B.

Example:

Screen A data	026	0509	1145	28
	350	1400	100	
Screen B data	026	072	004	029
	139	008	194	117

Interpretation of Screen A:
026 = (##) event number 26
0509 = (MMDD) May 9 (month 5, day 9)
1145 = (HRmm) 11:45 GMT
28 = (ZZ) error code 28
350 = (RATE) rate set at 350ml/hr
1400 = (VTOBI) volume to be infused at time of snapshot
100 = (VOLUM) total volume infused this infusion

Interpretation of Screen B:
026 = (##) event number 26
072 = (AAA) decimal representation of binary number 01001000* for main modes
004 = (BBB) decimal representation of binary number 00000100* for state modes
029 = (CCC) decimal representation of binary number 00011101*for physical modes
139 = (DDD) decimal representation of binary number 10001011*for sensor flags
008 = (EEE) decimal number representing keypad state input mode
194 = (FFF) decimal number representing the A to D value of the battery voltage
117 = (GGG) decimal number representing the A to D value of the pumping pressure

* Below is a sample conversion table for interpretation of decimal information. This table shows the conversion from decimal #139 (DDD) to binary #10001011.

Sample Conversion Table for Interpretation of Decimal Information

Decimal Number	139 (DDD)							
Bit	7	6	5	4	3	2	1	0
Binary Digit Value	128	64	32	16	8	4	2	1
Decimal to Binary Conversion	1	0	0	0	1	0	1	1

The chart for DDD is used to determine pump status from the binary number value.

4. Time and Date Display

```
hh:mm:ss GMT
MM/DD/YY
```

Display time (GMT) where hh is the hour, mm is the minute, and ss is the second. Display the date where MM is the month, DD is the day, and YY is the year. Exit by pressing ***Options*** or ***On/Off***.

5. Pump History Display - Hours of Operation, Volume Infused, Loading Cycles

```
Hrs XXXXX Liters
YYYYY Load ZZZZZ
```

Shows:
cumulative hours when the motor is running, where XXXXX ranges from 0 to 99,999 hours.

cumulative volume infused where YYYYY ranges from 0 to 99,999 liters.

number of loading cycles (door opened) where ZZZZZ ranges from 0 to 99,999 loading cycles.

Exit by pressing ***Options*** or ***On/Off***.

6. Charge History Display - AC, Charge, and Battery On Time

```
AC XXXXX  Charge
YYYYY Batt ZZZZZ
```

Shows:
AC on time where XXXXX ranges from 0 to 99,999 hours and represents the total time that the pump is on and plugged in.

AC charge time where YYYYY ranges from 0 to 99,999. This represents the total time that the unit is plugged in and the pump is off.

Battery on time where ZZZZZ ranges from 0 to 99,999 and represents the total time that the pump is on and powered by the battery, i.e. not plugged in.

The total pump on time or cumulative hours of operation is the sum of the AC on time and battery on time.

Exit by pressing ***Options*** or ***On/Off***.

7. Pressure (Calibrate Mode) Display

```
Pressure calib.
WWWWW XXXX YYY Z
```

Shows pressure (calibrate mode) where:

WWWWW ranges from 0 to 1919 and represents the position of the motor. It will show UNREF if the motor cam position is unreferenced. * will be shown in the first "W" position if a motor stall was detected.

XXXX represents the position immediately before the last motor "home" position realignment. It ranges from 0 to 1919, although if there is no significant motor slippage, expected display values are 0 to 40 or 1880 to 1919.

YYY ranges from 0 to 255 and is the raw analog to digital pressure reading from the display board. This value is read and the Message Display value updated at least twice per second. This permits occlusion alarm calibration to a known pressure by adjusting two potentiometers (see occlusion alarm calibration, section 5.10).

Z represents the pressure plate position switch, where '1' = cassette-in-position, '0' = no cassette present, and '-' = communication error when switch is read.

Pressure calibration is not allowed when the pump is not on AC power. The message will be:

```
Pressure sensor
calibrate on AC
```

If the pump is plugged in while this screen is showing, then the pressure sensor calibrate screen will be displayed.

Pressing ***Primary*** toggles motor direction. The default rate is 25 mL/h. This rate may be adjusted by pressing ***Rate*** and then entering a rate with the numeric keys (the run light will flash whenever a rate can be entered via the numeric keys). The entered rate will be accepted upon pressing ***Run***. The rate will be displayed in the rate field of the rate display. If the motor is running backwards then the pumping motion field of the numeric display will show a minus sign. If the motor is running forward or backward the run light will be solidly lit.

The motor may be stopped by pressing ***Hold***. When the motor is stopped the hold light will be lit.

Exit by pressing ***Options*** or ***On/Off***.

8. Baud Rate Selection

```
Baud rate: XXXX
↓↑ to change
```

This screen displays the current baud rate selection for the computer interface: 300, 600, 1200, 2400, 4800, or 9600. The default baud rate is 9600 baud.

Pressing the *1* (↓) or *3* (↑) keys advances the screen to the

next or previous baud rate. Pressing *1* (↓) when 300 baud is displayed results in 9600 baud being shown. Pressing *3* (↑) when 9600 baud is displayed will result in a baud rate of 300 being displayed. Pressing ***Options*** or ***On/Off*** accepts the last baud rate shown.

9. Language Selection

```
XXXXXXXX
↓↑ to change
```

This screen displays the current language of the pump.

XXXXXXXX represents

English
French
German
Italian
Spanish
Dutch
Swedish
Japanese

NOTE
Contact 3M Infusion Therapy to determine langauge availablility.

The *1* (↓) or *3* (↑) keys advance the screen to the next or previous language. Pressing *1* (↓) when the first language is displayed results in the last language being displayed. Pressing *3* (↑) when the last language is displayed results in the first language being displayed. Pressing ***Options*** or ***On/Off*** accepts the last language shown.

10. Battery Use Display

This displays how the battery was used.

```
Battery use
XXX hr: YYYYY
```

The value shown in location XXX represents the time increment that the pump was used on battery before being plugged into AC. There are eight increments:

0-1
1-2
2-3
3-4
4-5
5-6
6-7
7+

The value YYYYY can range from 0 to 99999 and represents the number of times that the pump was on battery for the hour increment indicated.

The *1* (↓) or *3* (↑) keys will advance to the next or previous increment, respectively.

Exit by pressing ***Options*** or ***On/Off***.

11. Display Model Number and Software Versions

This displays the model number and software versions of the infusion pump.

```
Model XXXX VY.YY
DB:Z.ZZ (MM:G.GG)
```

The value XXXX is either 3000 for micro/macro pump or 3100 for micro pump. Y.YY is the version (V) of software resident in the ROM memory of the main processor; Z.ZZ is the version of software in the display board microprocessor (DB); and G.GG is the version of software in the motor monitor processor (MM).

Exit by pressing ***Options*** or ***On/Off***.

12. Audio Alarm Test

```
Alarm Test
Press 1, 2 or 3
```

This screen allows the technician to verify the proper operation of the audio alarms.

Pressing *1* initiates the ***non-insistent*** alarm.
Pressing *2* initiates the ***insistent*** alarm.
Pressing *3* initiates the ***Back Up*** audio alarm.
Pressing any other key stops the alarm. Press ***Options*** or ***On/Off*** to exit.

NOTE
The hardware which produces the *Back Up* audio alarm is the same as that used by the *Continuous* alarm.

3.9 Analog to Digital Requirements

In addition to controlling the Message Display, rate and volume to be infused displays, and LED's, the display software must monitor a number of analog to digital conversion values. These are: pressure, battery level, cassette position, the ambient lighting level, and the LED/segment forward voltage drops. The LED/segment voltage drops are checked on power-up.

3.10 Pressure/Battery/Light/ Cassette Monitoring

An off-board CPU will periodically check the current analog levels for the pressure sensor input, the battery level, the pressure plate position input, and the photosensor used to measure ambient lighting. These levels are each measured at least once per second and their values (0-255) are accessible to the on-board CPUs. Decisions based on sensor readings require at least two reads of the sensor.

The pressure sensor input will be used to check for occlusions and alarm as necessary.

The pressure plate position switch indicates whether the cassette is in place.

The battery level input is used to check for low battery levels, or when a battery test is initiated. Low battery levels will result in the appropriate alarm message.

The ambient lighting level input is used to adjust the intensity of the LED's based on the current ambient lighting.

3.11 LED/Segment Monitoring

An off-board CPU will periodically (once per second) check the status of each individual LED and digit segment. If the LED or segment should be off, it will be checked to make sure there is no forward voltage drop. If there should be a forward voltage drop and it is absent, or it is out of an acceptable range, a fault will be reported to the on-board CPUs and a System Error alarm message will appear in the Message Display.

3.12 Start-Up Procedure

NOTE
The following is not a complete procedure for patient use. It is instead intended to acquaint technical personnel with the methods required to operate the pump for functional check and maintenance related operations. Complete procedures for pump use can be found in the operator's manual packaged with each pump.

WARNING
To minimize the possibility of unrestricted gravity flow, always close the lower roller clamp before opening the door.

CAUTION
To prevent pump and/or cassette damage, always open the administration set's upper clamp before closing the door.

1. Prime selected administration set according to its instructions (for functional check and maintenance procedures, a 20 drops/mL, non-checkvalve administration set must be used).
2. Pull door latch up and outward to open door (pump turns on automatically when door is opened).
3. Hold cassette with flat side facing you. Place cassette in pump by lining up four holes on cassette with cassette loading pins. Press cassette into place by running your finger around outside edges and down center to make sure it's firmly in place.
4. Place Safety Clip into clip retention slot and push completely forward.
5. Swing door closed and push in door latch.
6. Press ***Rate*** and enter desired rate, in mL/h. Verify rate displayed is correct.
7. Press ***Volume to be Infused*** and enter volume, in mL. Verify displayed volume to be infused is correct.
9. If desired, change Occlusion Alarm Setting (see description of ***Occlusion Alarm Setting*** key).
10. Open lower roller clamp and press ***Run***. The pumping indicator, on left side of rate display, shows that fluid is being delivered.

To stop infusion, press ***Hold*** (door may be opened to stop flow in an emergency). When infusion is complete, the ***non-insistent*** audio alarm will sound. KVO (Keep Vein Open) will appear in message display and the pump will switch to the KVO rate of 3 mL/h (if rate setting is less than 3 mL/h, KVO equals rate setting).

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Mechanical Systems

4.1 Linkage System

Refer to Figure 4-1 for discussion of the linkage system.

The Model 3000 and Micro 3100 Infusion Pumps employ a linkage system to move the cam housing/pumping mechanism between the *load position* and *operate position*. The *load position* is used to load and unload the fluid filled administration set. The *operate position* brings the pistons and valves of the pumping mechanism in contact with the cassette.

The pumping mechanism is spring loaded to keep it in the *load position* whenever the door is opened. When the door is closed the linkage mechanism is actuated by the handle/arm assembly and the pumping mechanism is drawn forward into the *operate position*. Once in the *operate* (door closed) *position*, the latch lever secures the pump mechanism in place.

Operating position is monitored by the microprocessor as it reads a signal from the cam housing switch positioned on the cam housing.

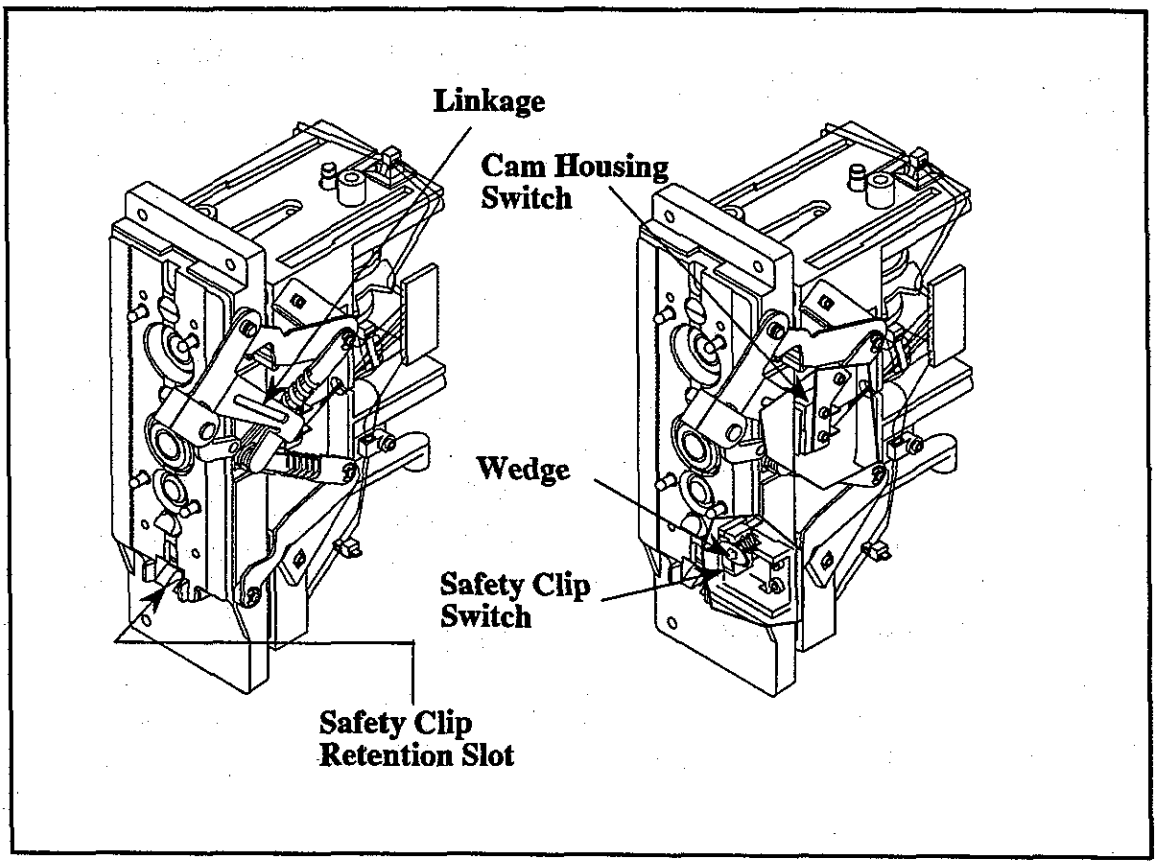


Figure 4-1
Linkage System/Safety Clip Switch

4.2 Cassette Housing and Door System

Refer to Figure 4-2 for discussion of the cassette housing and door.

The cassette housing and door system of the Model 3000 and Micro 3100 are designed for one step loading. Opening the door turns the pump on and causes the microprocessor to set the pistons and valves in the ready position. After a cassette is loaded the door can be closed by swinging the door shut and pushing the door latch in.

The cassette housing and door secure the cassette in the proper position for loading and operation. Cassette position is established by placing the cassette (flat side out) over 4 loading pins built into the cassette housing. The cassette housing is mounted to the front cover of the pump and is stationary.

The door is also mounted to the front cover using 2 hinge brackets. When the door is closed, it provides a flat, stable surface for sealing of the valves and manipulation of the fluid chambers by the pistons.

In the door is a spring loaded pressure plate. When a fluid filled cassette is placed on the cassette housing and the door is closed, there is a considerable amount of pressure developed in the cassette. The pressure plate is spring loaded to accommodate this pressure build up. The pump relieves the pressure by reversing motor direction and channeling the solution back up to the container.

Once the pressure has been reduced, the pressure plate springs push the plate toward the cassette housing. A position sensor mounted on the plate is activated when the pressure plate reaches a specified distance from the cassette housing. The microprocessor reads this sensor and determines if the pressure has been adequately relieved. If loading was successful, the pump can be put in run; if not, an ***insistent*** alarm will sound and an alarm message will be displayed.

The pressure plate also houses a pressure transducer used to monitor occlusion pressure. The transducer is positioned over the bottom piston (middle cassette chamber) and provides continuous pressure monitoring while pumping. Amplifier gain and zero offset are adjusted using trim pots R439 and R448 which can be accessed at the bottom of the door assembly. If pressure exceeds the chosen Occlusion Alarm Setting, an ***insistent*** alarm is generated.

In addition to the pressure plate and sensors described above, the door assembly also houses the display board, keypad, CPU3 memory chip, and photosensor.

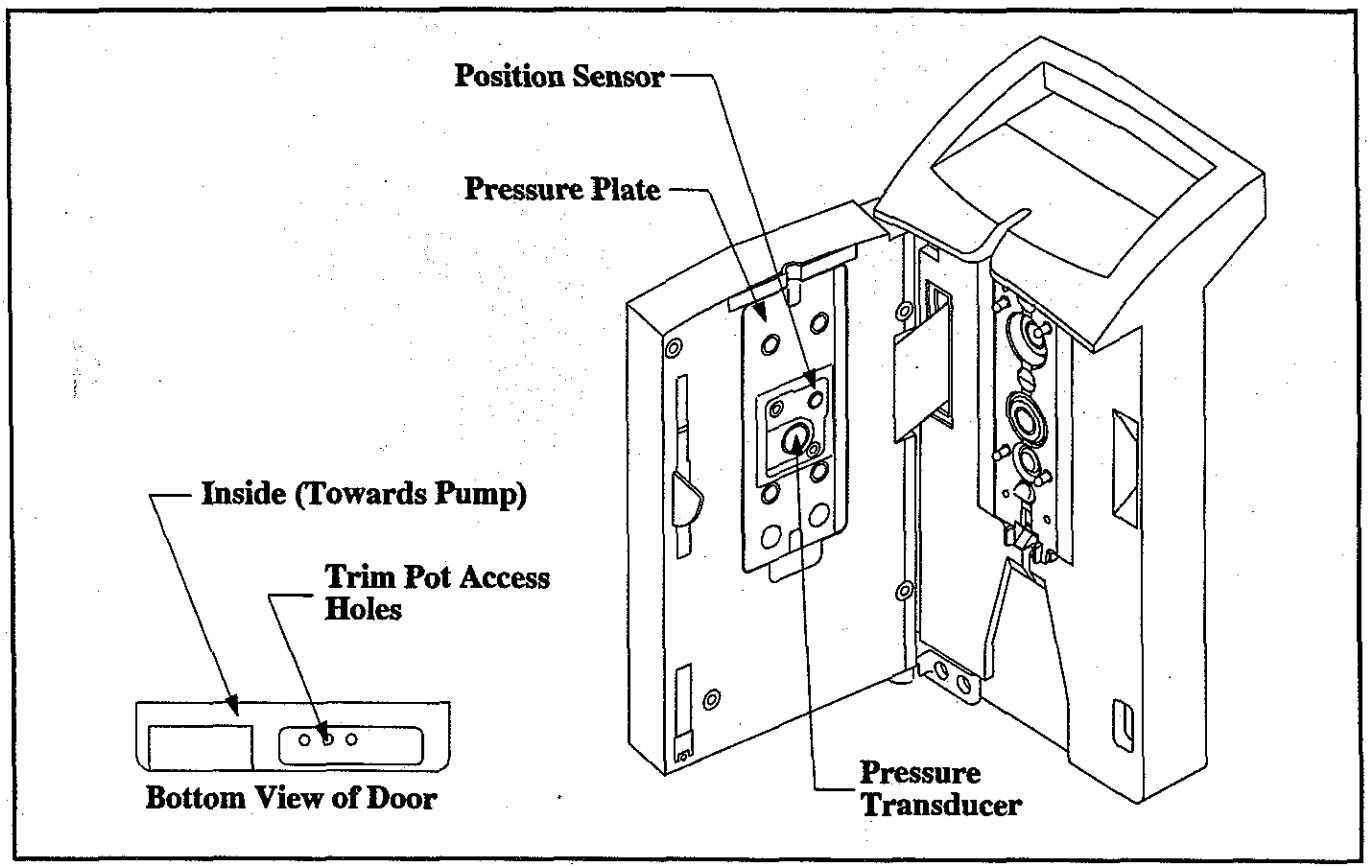


Figure 4-2
Cassette Housing & Door

4.3 Safety Clip Slot

See Figure 4-1 for discussion of the Safety Clip slot.

The Safety Clip, located on the administration set, is inserted into the safety clip retention slot on the bottom front of the cassette housing. The Safety Clip will occlude the IV tubing whenever the door latch is pulled out. When the door latch is pushed in, the arms of the Safety Clip are spread apart by the wedge inside the safety clip slot, thus allowing infusion.

4.4 Cam Housing Switch and Safety Clip Switch

Refer to Figure 4-1 for cam housing switch and Safety Clip switch description.

Two sub-miniature switches monitor the cassette loading process. They alert the microprocessor to Door Open and Safety Clip alarm conditions. If either switch is not activated the pump will not operate.

The cam housing switch (normally closed) is mounted to the upper right side of the cam housing. It is activated by the cassette housing as the pumping mechanism is drawn forward during the loading process. The cam housing switch is opened as the door is closed.

The Safety Clip switch (normally open) is mounted to the bottom front of the cam housing. It is activated by the Safety Clip on the administration set when the clip is inserted into the safety clip slot and the door is closed.

4.5 Cam Housing

Refer to Figure 4-3 for discussion of the cam housing.

The molded cam housing is coupled to the front housing of the Model 3000 and Micro 3100 via the linkage system. The cam housing acts as the main supporting structure for the electromechanical pumping mechanism (see Section 4.1) The stepping motor mounts to the lower portion of the cam housing with its shaft pointing upward. Coupled to the shaft is the vertical cam shaft which turns in bushing inserts. The encoder wheel and valve and piston cams of the pumping mechanism are molded on the cam shaft. These electromechanical components, as well as the overpressure piston and valve, two pumping pistons and valves, all operate within the cam housing.

Mounted to the cam housing are the cam housing switch, clip switch and flex wedge assembly, and the I/O circuit board.

4.6 Stepping Motor

See Figure 4-3 for motor discussion.

A four phase, synchronous stepping motor [3] is used in the Model 3000 and Micro 3100 pumping mechanism. The step angle is 7.5 degrees and the gearbox reduction ratio is 20:1.

The motor is operated by circuitry on the I/O board according to a control program in the microprocessor memory. To provide smooth rotation, the motor is half-stepped for rates 0.1 mL/h through 499 mL/h. At rates 500 mL/h and above the motor is whole stepped. CPU1 sends commands to U106 on the I/O board which sends on/off signals for each of the four motor coils. These signals in conjunction with a step pulse cause motor motion.

Due to the 20:1 gear reduction of the Model 3000 and Micro 3100 and half stepping, 1920 pulses yield one full revolution for rates of 499 mL/h and less. Each cam shaft revolution and the resulting cycle of the pumping mechanism delivers approximately 1.7 mL of fluid. Delivery of fluid to the patient is smooth since each mL is delivered in approximately 1130 increments. (The Model 3100 is half stepped at all rates.)

At rates of 500 mL/h and above, due to the gear ratio of 20:1 and whole stepping the motor, each mL of fluid is delivered in approximately 565 increments.

4.7 Cams, Pistons, and Valves of the Pumping Mechanism

See Figure 4-3 for the following discussion.

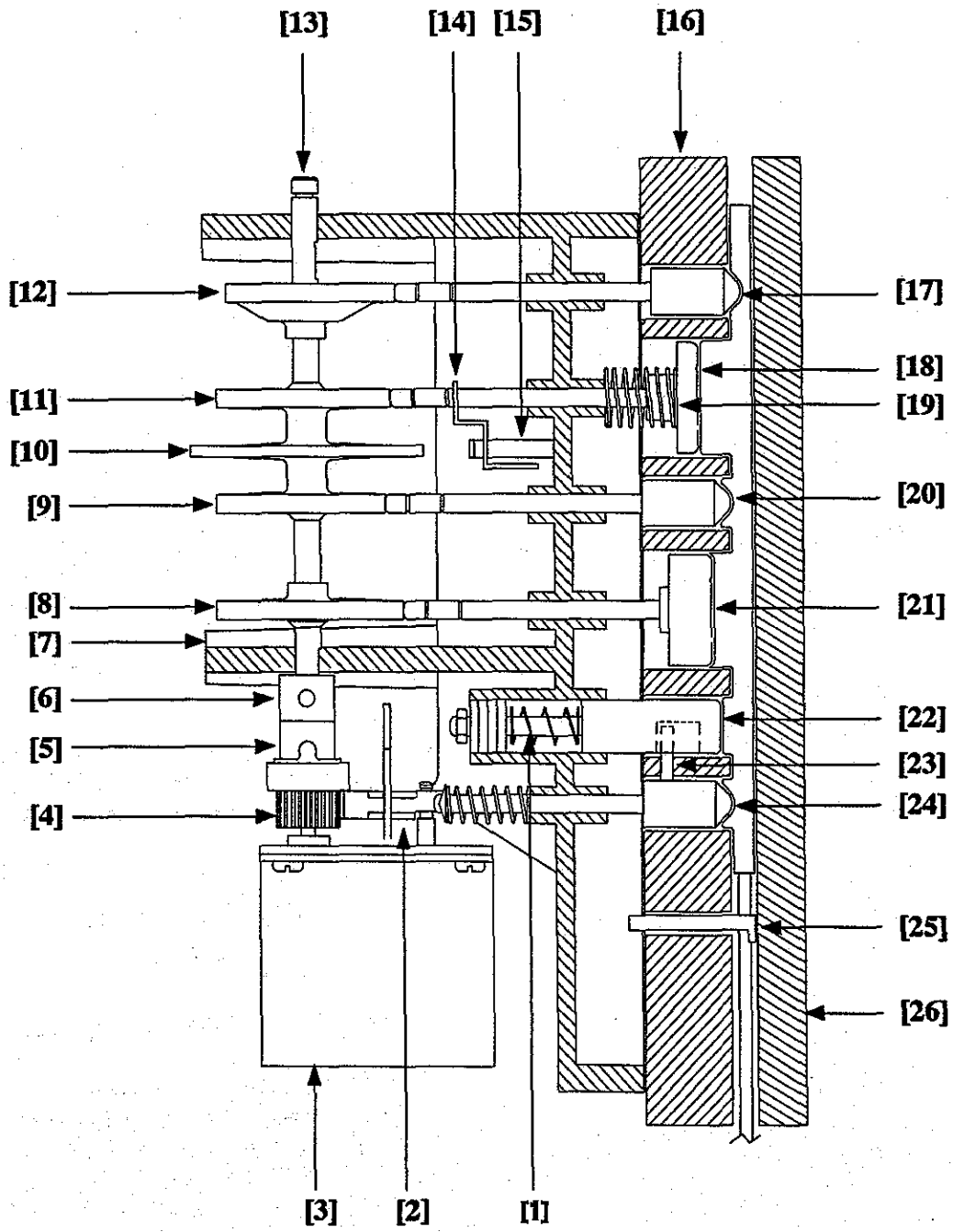
The motor's mounting shaft is connected to a vertically mounted cam shaft [13] by the motor coupler [4], interface coupler [5], and hub coupler [6]. Four cams [8], [9], [11], and [12], and an encoder wheel [10] are molded on the cam shaft. The cams actuate four horizontal shafts, which in turn drive two valves and two pistons which produce the pumping action.

Pumping Cycle Description:

See Figures 4-3, 4-4, and 4-5.

1. Cam shaft revolution causes the upper valve [17] to open, allowing flow to the upper cassette chamber (and upper piston [18]), and the lower valve [20] to close, not allowing flow between the upper and lower cassette chamber (lower piston).

   The smaller, lowest chamber on the cassette is in contact with the overpressure piston [22], and is the point where internal pumping pressure is continuously regulated (see



[1] Spring
[2] Swing Arm
[3] Stepping Motor
[4] Motor Coupler
[5] Interface Coupler
[6] Hub Coupler
[7] Cam Housing
[8] Piston Cam
[9] Valve Cam
[10] Encoder Wheel
[11] Piston Cam
[12] Valve Cam
[13] Cam Shaft
[14] Wire Contact
[15] Spring Contact
[16] Cassette Housing
[17] Upper Valve
[18] Upper Piston
[19] Piston Spring
[20] Lower Valve
[21] Lower Piston
[22] Overpressure Piston
[23] Connect Shaft
[24] Overpressure Valve
[25] Safety Clip Retention Slot
[26] Pressure Plate/Door

Figure 4-3
Pumping Mechanism Cut Away

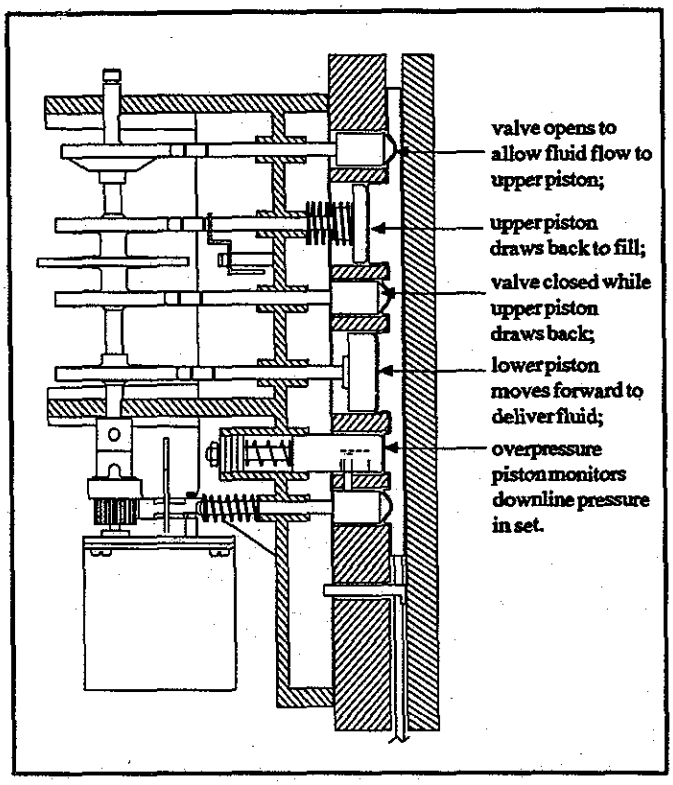

valve opens to allow fluid flow to upper piston;
upper piston draws back to fill;
valve closed while upper piston draws back;
lower piston moves forward to deliver fluid;
overpressure piston monitors downline pressure in set.

Figure 4-4
Pumping Cycle Description

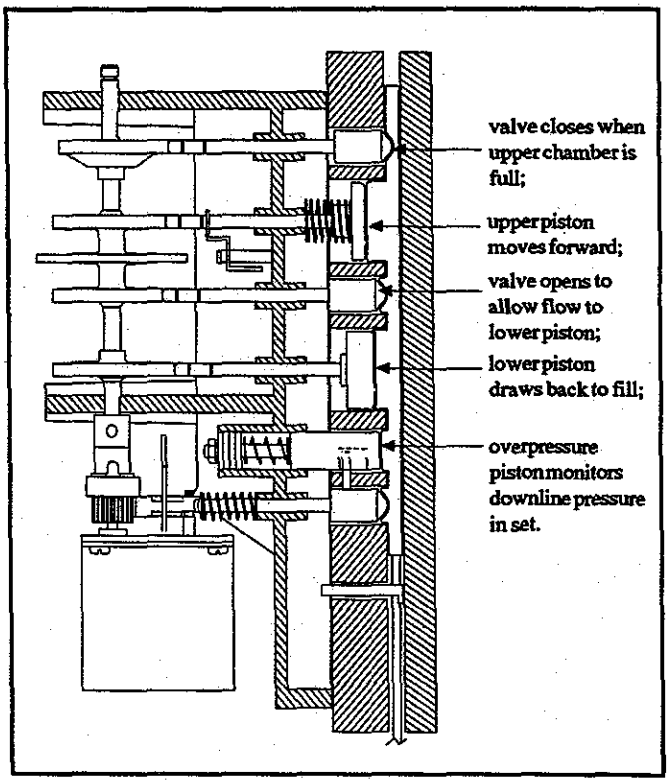

valve closes when upper chamber is full;
upper piston moves forward;
valve opens to allow flow to lower piston;
lower piston draws back to fill;
overpressure piston monitors downline pressure in set.

Figure 4-5
Pumping Cycle Description

Section 4.12).

2. The upper piston [18] begins to draw back as fluid flows from the upper tubing into the upper cassette chamber. At the same time, the lower piston [21] begins to slowly push forward, forcing the fluid in the middle cassette chamber into the lower tubing and toward the patient.

3. Once the upper piston [18] has moved fully back and the lower piston [21] fully forward, the upper valve [17] closes and the lower valve [20] opens. The upper piston [18] then begins to push forward to force the fluid in the upper cassette chamber downward into the middle cassette chamber, where the lower piston [21] is beginning to draw backward to receive the fluid. The upper piston moves forward delivering fluid more rapidly than the lower piston draws back, causing a continuous stream of fluid to be forced out the lower tubing to the patient.

4. The lower valve [20] closes and the upper valve [17] opens as the upper piston [18] reaches its furthest forward point of travel and the lower piston [21] its furthest back, and the cycle repeats.

The result of the above cam, piston, and valve action is a smooth flow of fluid through the lower tubing to the patient. Each full revolution of the cam shaft delivers approximately 1.7 mL of fluid as governed by the precise and unvarying travel of the pistons. The rate of fluid delivered is determined by the rate at which the motor is stepped.

4.8 Encoder Wheel and Interrupter

Refer to Figure 4-3 and 4-6 for discussion of the encoder wheel and interrupter.

The encoder wheel [10] is mounted to the cam shaft [13], which is turned by the stepping motor to drive the pumping mechanism. The interrupter assembly is mounted to the back of the cam housing (via the I/O board) so its emitter and detector arms straddle the encoder wheel. The light beam produced by the emitter is alternately allowed to reach the detector and then blocked by the teeth of the encoder wheel as it turns.

Data from the interrupter detector is read through the parallel to serial interface chip U108 on the I/O board. The microprocessor monitors the interrupter output in relation to the motor drive pulses delivered. If the microprocessor senses an incorrect response from the pumping mechanism, a system warning will be generated. The message '`System check/Turn off then on`' and ***insistent*** audio alarm result. In this manner, the encoder wheel and interrupter alert the microprocessor to binding, hesitation, or stalling of the motor and pumping mechanism.

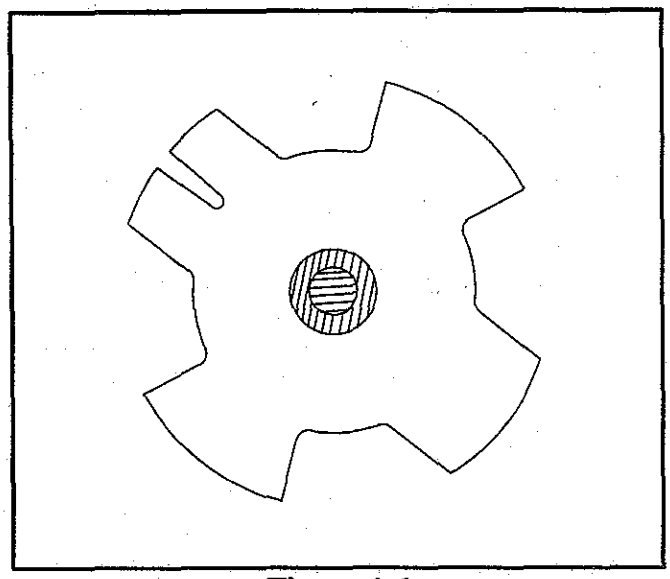


Figure 4-6
Encoder Wheel

4.9 Empty Bag Contacts

Refer to Figure 4-3 for discussion of the empty bag contacts.

The empty bag contacts consist of a rigid wire contact and a spring contact, and are used in detecting the 'No flow above pump' alarms. The wire contact [14] is connected to ground potential. The spring contact [15] is mounted to the cam housing. The position of the spring contact is adjusted by a set screw located on the right side of the cam housing. The empty bag contacts must touch briefly once per revolution of the pumping mechanism. Contact occurs only when the upper piston is in the major depression area of the metering cam, as illustrated in Figure 5-15.

The upper piston [18] is loaded to the out position by a light spring [19]. Pressure caused by the solution container and proper fluid height (see Table 2-1) overcome this spring tension and cause the upper piston shaft to maintain contact with the drive cam (metering cam) throughout the pumping cycle. An empty fluid container or inadequate head height allows the piston to lose contact with the metering cam. The wire contact fails to touch the spring contact, and an alarm results.

4.10 Sensors

1. Pressure Sensor

Occlusion pressure and alarm conditions are monitored by a solid state pressure transducer which interfaces directly with the middle chamber of the fluid filled cassette. The transducer is a differential pressure transducer which, when activated by a constant current source, provides an output voltage proportional to applied pressure. The output of the transducer is amplified by a two-stage instrumentation amplifier which provides output analog voltages in the range of 0 to 5 volts. Output voltages from the amplifier are read by the display board microprocessor via an 8-bit analog to digital converter.

When an 'Occlusion below pump' alarm occurs, the motor briefly backs off before entering hold. The overpressure condition is thus reduced while you locate and correct the cause of the backpressure. A swing arm closes the overpressure valve to prevent reverse fluid flow while the motor is backing off (see Section 4.11).

WARNING
The occlusion detection sensor detects downline back-pressure in the administration set, but is not designed to detect infiltration. In accordance with institution's policies and procedures, operator must periodically inspect patient's infusion site for swelling, temperature changes, and/or other signs of infiltration.

2. Pressure Plate Position Sensor

The pressure plate position sensor (housed in the pressure plate in the door) provides information to the display board microprocessor regarding the position of the cassette housing and pressure plate. The sensor itself is a microswitch that activates when the pressure plate comes within a specified distance from the cassette housing (when a cassette is in place).

3. Photosensor

The Model 3000 and Micro 3100 systems include a photosensor device used to monitor ambient light levels and adjust the LED display intensities accordingly. The photosensor is a photoconductive cell which has a cell resistance that varies inversely with illuminance. The cell resistance varies from approximately 10K ohms to approximately 1M ohms. The cell is designed into one leg of a resistor divider network, and the voltage generated across the cell is read by the display board microprocessor via the 8-bit analog to digital converter.

4.11 Overpressure Valve and Swing Arm

See Figure 4-3 for the following discussion.

The overpressure valve [24] is located directly below the overpressure piston [22]. The swing arm [2] is attached to the cam housing at the rear of the overpressure valve shaft. The toothed section of the swing arm engages the motor coupler and is held in ready position by a torsion spring. The swing arm rides on the toothed surface of the motor coupler while the pump is running. When the motor backs off, the swing arm catches on the motor coupler and forces the overpressure valve outward occluding the fluid pathway. In this way, reverse fluid flow is prevented whenever the pumping mechanism backs off.

In the event an administration set is loaded improperly, excess pressure can build up in the cassette. If this happens the pump will alarm and be maintained on hold. During this period, the excess pressure within the cassette pushes the pressure plate away from the cassette housing. In this situation the pressure spring mounted on the overpressure valve shaft will force the valve outward, keeping it in contact with the pressure plate and preventing gravity flow.

4.12 Backpressure Regulation

Refer to Figure 4-3 for discussion of backpressure regulation.

Proper performance of the pump depends on constant conformity of the fluid filled cassette to the cassette housing and pistons during the pumping cycle. A small amount of backpressure is therefore necessary within the cassette to maintain the proper cassette form. The overpressure valve [24] and overpressure piston [22] function together to regulate downline flow for the purpose of providing this necessary backpressure. Pressure must be great enough to maintain cassette form, yet kept below the threshold of the Low Occlusion Alarm Setting.

The overpressure valve provides backpressure to the cassette by restricting fluid flow during operation. The position of the overpressure valve and the amount of backpressure it provides is influenced by the overpressure piston.

The overpressure piston and valve are coupled by a vertical connect shaft [23]. The overpressure piston is slotted where it joins the connect shaft. This slot allows semi-independent movement between the valve and piston.

During operation the rear edge of the piston slot makes contact with the connect shaft. The piston assembly contains a spring [1] which is precisely calibrated for the proper force during manufacture. It is this spring force (which is applied to the overpressure valve via the shaft) that governs the internal pressure of the cassette.

Should a small temporary pressure increase occur within the cassette, the overpressure piston will be pushed to the rear. The vertical shaft is then disengaged from the piston. The internal pressure will also push the overpressure valve to the rear causing less flow restriction. The resulting decrease in pressure will allow the piston to move forward and engage the connect shaft, thus reasserting the spring tension to the valve. This restores the desired level of internal pressure to the cassette.

The preloaded overpressure valve opens as forward rotation of the pumping mechanism begins. The preload force is overcome when pressure reaches approximately 1 psi. However, the breakopen pressure varies and is sometimes higher than 1 psi.

To avoid nuisance occlusion alarms in the low occlusion pressure setting during start up, the pressure threshold is set to 4 to 5 psi temporarily. After a brief transition period, the alarm threshold reverts to 2 psi. The Low setting should only be used with lower flow rates.

4.13 Pole Clamp

The pole clamp is designed to function with pole diameters of .5 to 1.5 inches. It will support the weight of three Model 3000 and/or Micro 3100 infusion pumps. Turn the knob clockwise to attach the pump to the pole, and counterclockwise to remove the pump.

4.14 Modular System

The Model 3000 and Micro 3100 are equipped with a modular connection system which allows connection of up to 3 pumps for situations when multiple infusion lines are required. The modular system is designed so that any pump can be a Center, Left, or Right mounted pump. Only the Center pump (pump which is attached to IV pole) will accept attachment of another pump. This prevents connecting too many pumps, which could cause IV poles to tip.

To connect pumps:

1. Attach a pump to an IV pole using the pole clamp. Pump attached to pole becomes Center pump.
2. Attach another pump to either side of Center pump: align modular connectors, then slide pump into place. You can connect pumps either by sliding from the bottom up, or from the top down. Modular connector clicks to indicate pump is in place.
3. If desired, attach third pump to other side of Center pump.

To disconnect pumps:

1. Press modular disconnect button and simultaneously slide pump either up or down to disconnect. The button is only activated when the pump is lifted or lowered simultaneously in order to prevent an accidental bump that might cause a pump to fall.

Attaching a pump to a pole actuates the arm lever, causing the right and left modular disconnect buttons to retract. A pump can then be attached to either side of the pole mounted (Center) pump.

Electronic Circuit Description

4.15 Definitions

PROM: Programmable Read Only Memory.
LCD: Liquid Crystal Display.
LED: Light-Emitting Diode. A semiconductor light source that emits visible light or invisible infrared radiation.
NVRAM: Non-Volatile Random Access Memory. Electronic read/write memory which retains its data even when power is removed.
PCB: Printed Circuit Board.
SPI: Serial Peripheral Interface, a Motorola defined serial bus interface.
SRAM: Static Random Access Memory. Electronic read/write memory which does not need to be periodically refreshed.

4.16 Functional Block Diagram

Refer to figure 7.1 for the block diagram and system control discussion.

The circuitry for the Model 3000 and Micro 3100 Infusion Pumps is organized on 4 printed circuit boards, referred to as the CPU/Power Supply board, the RS232 Interface board, the I/O board, and the Display board. The CPU board contains the primary system controller and control logic as well as power supply and power control circuits. The I/O board includes the motor drive circuit for the system's stepper motor, the battery charger circuit, and interface circuitry for several of the system's sensors. The display board includes the interface circuitry for the keypad, LED and LCD displays, and an analog to digital converter for gathering miscellaneous sensor data. The RS232 Interface is piggybacked to the CPU/Power Supply board and handles data transfer between the pump and hospital host computer.

4.17 System Control

The high level circuit design for the Model 3000/3100 relies on a central system controller microprocessor, U15 (CPU1), with two peripheral microprocessors used for display control (CPU3) and fail-safe system monitoring (CPU2). The central controller interfaces to the peripheral microprocessors and all system I/O signals using both the Serial Peripheral Interface (SPI) bus signals defined on the microprocessor(s) and the microprocessor's dedicated I/O ports. All system operations, including data input and output, system state control, and interprocessor communications are initiated by the central microprocessor.

The first peripheral microprocessor, U402 (CPU3), is located on the Display board and is used to control the system's LCD panel, seven segment LED indicators and discrete LEDs. The Display board microprocessor receives commands from the central microprocessor and, from these commands, displays appropriate system status and alarm information. The Display microprocessor also interfaces to an analog to digital converter on the display board. The analog to digital converter is used to gather and relay various sensor information to the central microprocessor.

The second peripheral microprocessor, U8 (CPU2), is located on the CPU/Power Supply board and is used to monitor the motor output of the pump. This microprocessor receives information from the central microprocessor regarding expected fluid delivery rates and compares actual motor stepping rates to the expected rates. Upon detection of an error, the monitor microprocessor has the ability to disable motor stepping and initiate a ***Continuous*** audio alarm. Under normal conditions, the monitor microprocessor must periodically receive valid commands and respond to the central microprocessor, assuring basic soundness of both microprocessors. As with motor stepping errors, communications problems between the two microprocessors will also force the pump into hold mode and initiate a ***Continuous*** audio alarm.

4.18 Power

Refer to figure 7.2 during the description of power routing.

The Model 3000 and Micro 3100 accept standard 100/120 VAC or 220/240 VAC as the primary power source, and include a sealed lead-acid battery as backup supply to provide uninterruptable system operation. The CPU board provides the bulk of the power management, converting AC line voltage to DC, controlling the power switching between the primary and battery supplies, and generating the +5V DC voltage used by the majority of the logic circuitry in the pump. In addition to voltage regulation and control, the power supply electronics provides several status indicators to the system microprocessors, including AC ON, Power Fail (PFD), Battery On (BATT SW), and RESET. Also, a battery charger circuit on the I/O board provides rapid charging of the battery and is activated whenever AC power is available.

4.19 Interface Description

Inputs to the Model 3000 and Micro 3100 systems include keypad entries by the user, as well as signals from numerous alarm and status sensors. These sensors monitor the following:

- Occlusion (system pressure)
- Battery voltage
- Ambient light (for display adjustments)

- Air in fluid path
- Motor encoder wheel movement
- Empty bag status
- Door position
- Pressure plate position
- Safety Clip position

The primary system output is fluid delivery, achieved by pulsing a 12V, 4-phase stepper motor, which drives the system's dual-piston pumping mechanism. In addition, the electronics also provide the user with alarm and status information via a 2x16 character LCD module, an LED numeric display, and discrete LEDs.

4.20 Interconnection Summary

The tables in Section 7 specify all of the connectors on the three Model 3000 and Micro 3100 circuit boards. The primary connection throughout the system is a 34-pin ribbon cable (SPI) which carries signals to and from each of the three boards.

4.21 Detailed Design

The Model 3000 and Micro 3100 use surface mount component technology on all PC boards. The boards are a multi-layer design utilizing an internal ground layer, a 5 volt supply grid, and surface layers for component traces.

4.22 CPU/Power Supply Board

4.22.1 System Control Unit (CPU1)

As shown on sheet two of the CPU/Power Supply board schematic, a Motorola 68HC11F1, U15, is used as the central system control microprocessor, configured in an expanded-nonmultiplexed mode so that it can address 64K of external memory through a 16 bit external address bus and an 8 bit external data bus. Using this external memory space, the microprocessor interfaces to a 64 Kbyte PROM device and a 2 Kbyte battery-backed SRAM device.

As mentioned above, the Serial Peripheral Interface (SPI) is used to provide communications between the central microprocessor and the two peripheral microprocessors, and also provides an interface for various system I/O functions. The signals associated with this interface are called MOSI, SCK, MISO, and SS'. As illustrated in the block diagram in Section 7, the SPI is used for communications between the System Control Unit and the following modules of the pump system: keypad unit, display control unit, motor monitor microprocessor and the switch sensor unit.

In addition to the SPI interface, the 24 general purpose digital I/O bits (on ports A, E, and G) on CPU1 are used to perform a variety of sensing and control tasks. Table 4-1 on the following page provides a list of these signals, along with description and pin location.

To provide additional I/O signals, an 8-bit addressable latch (U19) is included on the CPU/Power Supply board. The latch outputs can be modified by setting ADD0, ADD1, ADD2 to correspond to the latch output which is to be changed, then the selected latch is changed by placing either a 1 or 0 on LDATA and strobing the enable pin low on the appropriate latch (WRDIS1 for U19). Output signals generated via this latch include:

CPU3SS: slave select for Display board microprocessor
OFFCPU1: microprocessor control power-down signal
CPU2AR': reset signal for audio monitor circuit
SHTDWN: shutdown signal for RS232 components
RTS: Ready-to-Send RS232 signal
AUDIO1, AUDIO2, and AUDIO3: drive signals for audio circuit

Refer to the power control unit (4.22.6), audio control circuit (4.22.4), and the display control unit (4.24.2) for specific information on how these additional control bits are used to control those elements of the system.

U13, a three-state buffer on the CPU/Power supply board, provides appropriate multiplexing of SPI and I/O address signals between the on-board motor monitor microprocessor (CPU2) and relevant off-board circuitry.

4.22.2 Motor Monitor Microprocessor (CPU2)

The CPU/Power Supply board includes a 68HC705C8 microprocessor, U8, used to monitor CPU1, and in particular to verify that the system stepper motor is being stepped at the appropriate rate. The microprocessor communicates with CPU1 primarily through the SPI port on both microprocessors, with seven additional I/O lines used to relay status or state information between the microprocessors and provide necessary system backup control. The seven I/O signals are defined as follows:

Inputs:
- (PA0) CPUI Data (IC3)
- (PA1) CPUI Data (IC2)
- (PA2) CPUI Data (IC1)
- TCAP CPU1MS motor "step" signal from CPU1

Outputs:
- CPU2 AUDIO, initiates backup audio alarm (PB0)
- OFFCPU2 , signal to allow battery *On/Off* switch (PB1)
- CPU20DS, motor enable/disable signal

Table 4-1: Miscellaneous I/O Signals on System Control Unit (U15)

Signal Name	Description	Pin on CPU1 (U15)
AC ON	Active low when the unit is plugged into AC power.	PE0 (59)
PNL LOCK	Toggled high or low with the Keypad Lockout Button on the back of the pump.	PE1 (61)
CTS	Pulled high by R58. Clear-to-send signal for use by the serial communications interface (SCI).	PE2(63)
AUX OK	Low when there is auxiliary battery power. Auxiliary battery power is available whenever the battery is switched on and the battery and Aux Batt fuses are functioning correctly.	PE3 (65)
AUDIO ON	Active high when the audio unit determines that the alarm being generated is acceptable.	PE4 (60)
BAT SW'	Active low when the unit is being powered by its rechargeable battery and power is turned on.	PE5 (62)
ON KEY	Active high when the *On/Off* key on the keypad is being pressed.	PE6 (64)
ADD0	Address line 0 for the extended control bits on U19 and the I/O and display boards.	PG0 (27)
ADD1	Address line 1 for the extended control bits on U19 and the I/O and display boards.	PG1 (26)
ADD2	Address line 2 for the extended control bits on U19 and the I/O and display boards.	PG2 (25)
WRDIS1	Latch control signal for the extended control bits on U19.	PG4 (23)
LDATA	Latch data line for the extended control bits on U19.	PG3 (24)
RAME1	SRAM enable control from CPU1.	PG6 (21)
RW'	Output enable control for EEPROM1 (U17) and SRAM (U18) which is connected to CPU1 (U15).	R/W' (5)
BACKUP AUDIO	Audio signal from CPU1 to the audio unit.	PA7 (35)
CPU1MS'	MotorStep. Inverted by U14 to become CPU1MS for high side motor stepping pulse.	PA6 (36)
MTRSTRB'	MotorStrobe. Inverted by U12 to become MTRSTRB for strobing motor step pattern.	PA5 (37)
PFD'	Active low upon AC power failure to interrupt CPU1.	XIRQ (18)
SENSTRB	SensorStrobe. Inverted by U14 to become SENSTRB' for I/O sensor reads.	PG5 (22)
KYSTRB	KeyStrobe. Inverted by U12 to become KYSTRB' for keypad reads.	PA4 (38)

The motor monitor software design requires that CPU2 periodically receive information regarding the expected fluid delivery rate of the pump via the SPI bus, and from this information calculates an expected motor step rate. CPU2 continually monitors the CPU1MS signal (which steps the motor) and compares the actual motor step interval to the expected step rate. If the two values do not match within a given error tolerance, CPU2 will disable the motor by driving CPU2ODS low and will initiate an audio alarm by driving CPU2 AUDIO low. CPU2 will initiate a similar alarm condition if it fails to receive communications from CPU1 within a defined time-out period.

Additional output signals generated by the motor monitor microprocessor include OFFCPU2. OFFCPU2 is a signal used by the power control circuit (section 4.22.6) which allows the unit to be powered-down via the ***On/Off*** key in the case of a failure of CPU1. (CPU1 software normally controls the power-down of the system independent of CPU2.)

4.22.3 Nonvolatile Memory

The nonvolatile memory on the CPU board is a Mostek battery-backed SRAM (U18), which is pin and function compatible with standard 2Kx8 SRAMs. This device also contains a real-time clock, a crystal, a power-fail chip deselect/write protection circuit, and a long-life lithium carbon mono-fluoride battery.

The SRAM is in read mode whenever the WRTENBL (write enable) pin is high and the E (chip enable) pin is low. The device architecture allows ripple-through access (changing addresses without removing chip enable) to any of the 2048 address locations. A complete read cycle takes 250 nanoseconds from address valid to valid output.

The SRAM is in write mode whenever the WRTENBL and E inputs are held low. The start of a write is referenced to the latter occurring falling edge of either WRTENBL or E. A write is terminated by the earlier rising edge of WRTENBL or E. The addresses must be held valid throughout the cycle. A complete write cycle takes 250 nanoseconds from address valid to end of write.

The G/OUTPT pin is an output enable that is used only when reading from the SRAM. The data I/O pins on the part will remain in a high-impedance (tri-stated) condition until the G/OUTPT pin is brought low.

Only CPU1 in the system control unit may read or write the contents of the SRAM.

4.22.4 Audio Circuit

The audio unit schematics are on the lower half of sheet 1 of 3 of the CPU/Power Supply board schematics. The function of the audio circuit is to provide a fail-safe alarm system such that if the primary alarm fails, the secondary system will detect the failure and generate a ***Back Up*** audio alarm. This is accomplished through the use of two piezo-electric transducers with independent drive circuitry. The fail-safe design uses one transducer to provide the primary audio alarm signal and uses the second as both a microphone to monitor the primary alarm and a backup speaker if the primary alarm fails.

The audio unit may be divided into the following sub-circuits according to their functions:

- Audio driving circuit
- Sound shaping circuit
- Audio verifier circuit
- Emergency oscillator circuit.

Audio Driving Circuit
Audio alarm generation on the Model 3000 and Micro 3100 is controlled by a MicroChip PIC16C54 microcontroller (U16). This device receives the following inputs: AUDIO1, AUDIO2, and AUDIO3. Together, these three signals provide commands to the audio microprocessor required to initiate ***insistent, non-insistent,*** and key-click audio outputs.

Based on those three inputs, the device provides two outputs:

FREQ OUT :	frequency pulse to drive the speaker
ENV OUT :	On/Off envelope for speaker signal

These outputs are coupled through transistors and an inverting buffer (U9) to provide a differential drive signal to the primary audio speaker. Jumpers JP2, JP5, JP6 and JP11 are included to provide the option of selectable alarm tone sequences.

Sound Shaping Circuit
The sound shaping circuit is used to give a resonant "bell" quality to the tones generated on primary speaker A. The circuit does this by exponentially decreasing the supply voltage to the inverting buffer (U9) at the end of each separate tone through transistor Q12, Q13, Q8, and associated discrete components.

Audio Verifier Circuit
The audio verifier circuit uses a secondary speaker B as a microphone to listen to tones generated by speaker A. The audio signal is coupled to this circuit using C20 and then amplified and fed to the FYI input of U11, which is a 14-stage binary ripple counter with oscillator. The Q9 output from U11 (AUDIO OK) goes high when the circuit has verified the presence (at speaker A) of an audio signal by "counting" between 512 and 1023 cycles by the audio signal. If the system expects the primary speaker to be sounding and AUDIO OK remains low, then a fault condition will be detected by the system controller. Once

the AUDIO OK line is set high, it must be reset using the CPU2AR' signal (active low) before the audio signal may be again sampled and verified. The AUDIO OK signal is read by CPU1 on PE4 and the CPU2AR' signal is strobed low (reset) by CPU1 via U19 pin 11.

Emergency Oscillator Circuit
If a system fault is detected, the emergency oscillator circuit is designed to be activated by either CPU1 or CPU2. The two signals which feed this circuit are CPU2_AUDIO' and BACKUP_AUDIO'. The circuit uses a 14-bit ripple counter with oscillator to produce a fixed frequency tone on Speaker B whenever drive signal is activated (low).

4.22.5 Power Supply

The Model 3000 and Micro 3100 electronics are intended to be powered primarily from AC Mains voltage, however a sealed lead-acid battery is included in the pump as a back-up supply, providing approximately 6 hours of pump operation. The power operates on either 100-120 VAC or 220-240 VAC, selected by SW1. For 100-120 VAC operation, fuse F1, specified for 110-120VAC operation, is inserted and jumper JP7 is shorted. 220-240 operation requires removal of JP7 (open) and insertion of fuses F1 and F2 with appropriate ratings for the higher voltage range. Sheet 3 of the CPU/Power Supply board schematic describes the primary power supply circuit, where line power is converted to +18VDC through a diode bridge and switching regulator (U22) with overvoltage "crowbar" protection (U23).

As shown in Section 7, DC supply voltages are generated on each of the three Model 3000 and Micro 3100 circuit boards to meet the power requirements of individual circuit blocks. Primary DC power, labeled V+, is generated on the CPU/Power Supply board and is taken from either the +18V supply when AC power is applied or the battery voltage when AC power is not available. V+ is used to generate the +5V supply which is used on all three circuit boards for general logic circuits. U2, a switching regulator, generates the +5V supply.

4.22.6 Power Control

The responsibility of the power control circuit, shown on the top half of sheet 1 of the schematic, is to control the ***On/Off*** switching of the battery supply and to generate logic signals indicating the state of system power. The power control circuit does not directly turn the pump on and off. The primary intent of the power control circuit is to allow microprocessor controlled power-down of the device when operating on battery to ensure that status data can be written to the system's non-volatile memory at power-down. The pump is turned on and off by the central microprocessor.

The Model 3000 and Micro 3100 central microprocessor continually monitors ***On/Off*** presses and activates the displays, keypad, and other active functions when appropriate to turn the pump "on". Whether the main source of power is supplied by AC or battery affects the behavior of the central microprocessor. When the pump is plugged in to AC power, the microprocessor runs continually, tracking system status during both "on" and "off" states. On battery power, the microprocessor runs only during system "on" state, disconnecting the battery supply immediately after ceasing active system functions (displays, etc.).

On/Off control is determined by several logic signals including:

- OFFCPU1 - control signal from P1 to disconnect battery
- OFFCPU2 - control signal from P2 to disconnect battery
- ON/OFF - signal from On/Off key on front panel
- BAT_ SW - signal used to connect/disconnect battery, generated from above signals

The BATT_ SW signal is the primary output of the power control circuit and is used to control a switch (Q2) which connects the battery to the main system power voltage, V+. Components U3 and U4 are used to generate the logic for the battery switching and are powered by a supply voltage which is always energized through diode coupled connections to +18V, Vbatt, and AuxBatt (a secondary connection to the battery via a second fuse).

To switch the battery "ON", one of two logic events must occur. The SET pin on the D flip-flop is connected to +18V through a resistor bridge and ensures that the battery voltage is "on" whenever +18V is applied. Because +18V and VBatt are both diode coupled to V+, switching VBatt "ON" while the +18V (AC generated) supply is connected does not require current from the battery. It does however provide back-up battery power whenever +18V is removed from the pump so that the system microprocessors have power to control system power-down. (This is necessary when removing AC power from the pump when the pump is in the "OFF" state.) The other method of switching the battery "ON" echoes the system "ON" sequence of pressing ***On/Off***. Toggling the On/Off signal while BATT_SW is low will toggle the D flip-flop and the BATT_SW will go high connecting the battery to V+.

The design also includes two methods for switching the battery "OFF" (disconnecting the battery from V+). Under normal operation, the battery is disconnected when microprocessor 1 asserts the OFFCPU1 signal. This signal is tied to the RESET pin on the D flip flop and forces the BATT_SW signal low. It is important to note that if the microprocessor attempts to disconnect the battery while the +18V supply is energized, both SET and RESET pins on the flip-flop will be high and the BATT_SW signal will remain high. A second method for switching the battery "OFF" allows either microprocessor to disconnect the

battery under system fault conditions. If the motor monitor microprocessor detects a potential fault in the main microprocessor, the monitor microprocessor will exert its OFFCPU2 signal. Once asserted, this signal then allows the battery to be disconnected when the ON/OFF signal is toggled.

The following logic equations summarize the battery ON/OFF switching logic:

BATT_SW on — off = (OFFCPU1 and +18V low)
or (OFFCPU2 and ON/OFF pulse and +18V low)

BATT_SW off — on = ON/OFF
or +18V high

The power control circuit also generates the following power status signals:

- PFD' - indicates a power fail on the V+ main system voltage supply, active low
- AUX_OK' - indicates power on the AUX_BATT line, active low
- RESET'- main system reset signal active when +5V supply is <4V or >6V, active low
- AC_ON - indicates AC power connected, active low

4.23 I/O Board

The I/O board includes motor control and drive circuits, sensor interface circuitry and connector, and a battery charger circuit. I/O drive signals for the motor are generated on the CPU board and gated through a 74HC173 3-state quad flip-flop device (U106). I/O signals to the sensor interface are provided via a parallel to serial shift register (U105).

4.23.1 Motor Control

The motor control circuit on the I/O board allows the system controller to independently drive each of the four coils of the system's stepper motor. The CPU board sends commands to U106 to generate "On/Off" signals for each of the four coils. These signals, in conjunction with a step pulse (CPU1MS'), initiate motor motion. CPU1 on the CPU board initiates all motor stepping through its I/O data bus while CPU2 monitors motor stepping via the CPU1MS' signal and enables/disables the motor with the CPU20DS signal.

To step the motor, the appropriate coils or phases of the motor must be energized by asserting signals PHASE A, PHASE B, PHASE C, and PHASE D in the correct pattern, assuming that the CPU20DS SIGNAL is low. Asserting the appropriate phase signals connects the negative side of the chosen coils to ground through transistors Q107-Q110 and connector P103. To step the motor, a step pulse signal approximately 5msec long is asserted through U101 and U107 which connects the positive side of all coils to +10V through transistors Q111-Q113. Between motor steps, the positive side of the coils are normally connected to +5V to provide "holding" current necessary to keep the motor in position. Zener diode D107 is important to the motor drive circuit as it limits the fly-back voltage created after switching the motor coils. This not only prevents damage to the drive transistors, but also rapidly dissipates the energy in the coils allowing for increased switching speeds.

For full step operation, the proper sequence of "on" or energized coils is :

AB-BC-CD-DA (two-phase "wave" drive)

For half-step operation, the proper sequence of "on" or energized coils is :

AB-B-BC-C-CD-D-DA-A

4.23.2 Switch Sensor Interface

The switch sensing unit (U105 and associated components) provides information to the system control unit concerning the following switches and sensors: interrupter detector, door switch, empty bag switch, clamp switch, and air detector. A 10-pin connector, P102, is used to connect the switches and sensors to the I/O board. Data from each of the sensors is read by the system control unit through the parallel to serial interface chip, U105. Data is communicated to the system control through SPI signals SCK and MISO.

Interrupter Detector
The interrupter detector is an opto-encoder device which is used to detect rotation of the pump camshaft. An LED/photodetector device straddles an encoder wheel on the pump camshaft and produces signal transitions within every 45° of motor rotation. To conserve power, the opto-encoder's light source is energized immediately before the output signal is read by the system control unit and then immediately deactivated. The control signal for the opto-encoder is generated by U101, an 8-bit addressable latch from CPU1 I/O signals. CPU1 communicates to U108 via U13 on the CPU/Power Supply interconnected at P101/P200.

Air Detector
An air detector opto-encoder device is used to detect air bubbles in the fluid path. The light source in the device is energized periodically and the output signal read by the system controller to determine if air bubbles exist. The output signal is normally high when the light source passes entirely through fluid, however when air is present, the light beam is refracted at the air/fluid interface producing a low output. The output of the opto-encoder is latched by a D flip-flop, U103, so that very brief signals can be detected

(possible for small air bubbles and/or high flow rates.) Once set, the D flip-flop (U103) must be cleared by the system control unit by asserting the AIR_RESET signal from U108 pin 12 to the reset line of U103.

Switch Sensors
The I/O board also provides the circuit interface for the following switches:

DOOR SWITCH: coupled to the door handle and activated when the door is open
CLAMP SWITCH: coupled to the free-flow clamp and activated when clamp is inserted
EMPTY BAG: positioned in the upper portion of the pumping mechanism and indicates a lack of fluid in the cassette

These switches are all coupled to the system controller via input/control and signals on U108 pins 5,6, and 7, and serial output data from U105 pin 13.

4.23.3 Battery Charger

U109, a Unitrode UC3906, is a battery charger/controller for use with sealed lead-acid batteries. It contains all of the necessary circuitry to optimally control the charge and hold cycles for the 12 volt battery. This IC monitors and controls both the charging output voltage and current through three separate charge states: a high-current bulk-charge state, a controlled over-voltage state, and a precision float-charge state. The circuit uses current and voltage sensing combined with sequenced current and voltage control to maximize battery capacity and life.

At power-up, the device enters the bulk charge (constant current) state and supplies approximately 180 mA (Imax) of charging current to the battery. The chip monitors the battery voltage and exits bulk charge mode when the battery voltage increases above 14.0 volts (V12). At this point, the battery enters the overcharge mode, charging the battery at a constant 14.7 volts (Voc) and monitoring the charge current. When the charge current drops below 50mA (Ioct) in overcharge mode, the charger exits overcharge mode and enters float mode, applying a constant 13.8 volts (Vf) to the battery. In float mode, the charger monitors the battery voltage and attempts to maintain this float voltage. If the battery voltage is drawn below 12.4 volts (V31), the three-phase charging sequence will begin again.

The charging voltages invoked by the charger circuit are proportional to an internal voltage reference. This reference has a temperature coefficient equal to the recommended compensation of most battery manufacturers, and assuming the charger circuit is located near the battery, battery charging should be optimized through the expected temperature range. (Refer to the Unitrode IC Databook for additional details concerning the battery charging chip.)

4.24 Display Board

The Display Board can be broken down into five major functional blocks: keypad unit, analog sensor unit, 7-segment display unit, LCD unit, and pressure plate position sensor. They are interfaced to the system control unit (CPU1) on the CPU/Power Supply Board via the main I/O bus and SPI interface cable. The keypad unit provides input from the user. The analog sensor unit senses battery level, pressure, ambient light level, and cassette position. The 7-segment display unit provides numeric information to the user. The LCD unit provides alphanumeric information to the user.

The display board communicates with the system control unit on the CPU/Power Supply board via a 34-pin connector (P401). Modules incorporated into the display board are:

Keypad unit

Analog Sensor Unit
- Pressure Sense Differential Amplifier
- Ambient Light Sensor
- Low Battery Detect
- LED Segment Voltages
- +8V Regulator and A/D reference voltages

7-Segment Display Unit
- Display Control Unit

Multiplexed LED Display
- Segment Latch
- Digit Decoder/Latch

LCD display
- Buffer
- Contrast Adjust
- EL Backlight

Pressure Plate Position Sensor

4.24.1 Keypad Unit

The 16-pin keypad connector (J403) connects the keypad to the keypad unit's circuitry. The keypad may be scanned by alternately enabling each of the 4 rows of the keypad and examining the status of the 8 columns to determine the row/column of the button that is being pressed.

To select the row of the keypad that is to be examined, CPU1 sends the appropriate command over the SPI bus, selecting a row via U410. Since the column inputs are pulled high by a 47K-ohm resistor network (RP 401), the row that is to be examined should be selected low and the other rows should be selected high.

After selecting the row to be examined, the columns may be

examined via U412, again with communication to CPU1 on the SPI bus.

4.24.2 Analog Sensor Unit

The analog sensor unit consists of circuits which monitor:

- The charge status of the rechargeable battery
- Pressure in the fluid line
- Ambient light level
- Function of the display LEDs.

The workhorse of the analog sensor unit is the MC145041 (U408) 11-input A/D converter with serial output. Signals are fed to U408 in the following manner:

- The eight anode-driving signals are fed to inputs AN0-AN7 of U408.
- The voltage of the rechargeable battery is represented to input AN8 through the output of a 1/3 voltage divider.
- The ambient light level sensor output that comes from a photo detector is fed to input AN9.
- The pressure sensor outputs are fed to input AN10 from the differential amplifier output at U409 pin 7. Pressure sensor inputs originate at J404, pins 2 and 4. Amplifier gain and zero offset are adjusted using R439 and R448 respectively.

Since one of its functions is to monitor the rechargeable battery, the analog sensor unit is powered by the rechargeable battery (since AC power may not be available at all times). The A/D converter and pressure sensor are powered by the output of an 8-volt voltage regulator which is generated from the 12V battery and may be turned on and off by output PC0 of CPU3.

The MC145041 is read by CPU3 via pins PC4-PC7, which are connected to the serial clock, chip select (active low), data in, and data out lines of the A/D converter respectively.

4.24.3 7-Segment Display Unit

The 7-segment display unit consists of two sets of five 7-segment displays, 6 colored LEDs, and the circuitry that drives the displays and the LEDs.

The 7-segment displays are of the common-cathode type, and five of the six colored LEDs are connected to have a common cathode.

The eight anodes (7 segments + decimal point) on each of the ten 7-segment displays are driven by common outputs from an 8-bit latch (U403) that are each current limited by a series resistor (comprised of two resistors connected in parallel). Five of the six colored LEDs have their anodes driven by five of the same outputs that drive the anodes on the 7-segment displays. The display control configures the 8-bit latch from its port A (PA0-PA7) and loads the latch by setting its TCMP output low.

The common cathode on each 7-segment display and the common cathode on five of the six colored LEDs is indirectly driven by a 4-to-16 line decoder (U404). The outputs from the decoder are buffered by single gates from a ULN2004A (U405, U406) to provide sufficient drive for the display cathodes. CPU3 configures the decoder from its port B (PB0-PB4), where PB0-PB3 selects the output and PB4 selects the logic level to be set.

This configuration leads to a multiplexed mode of operation, where each 7-segment display and the set of five diodes can be operated at a maximum 1/11 (9%) duty cycle. The firmware in CPU3 handles this multiplexed operation so that the system control unit only needs to tell CPU3 what is to be displayed.

The sixth LED (DS416) indicates that AC power is on. Its anode is supplied by pin 27 of connector P401 through a 4.7K-ohm current-limiting resistor, and its cathode is connected to ground.

4.24.3.1 Display Control Unit

The display control unit (CPU3) is a Motorola 68HC05 micro controller U402. CPU3 has a serial peripheral interface SPI (used to communicate with the system control unit) and three 8-bit general purpose I/O ports (A, B, C). Port A is connected for communications with the 7-segment display unit and LCD unit. Port B provides additional control signals for the LCD unit. Port C provides enabling controls for the LCD unit, 7-segment display unit, and the analog sensor unit. CPU3 also contains on-chip RAM and firmware. The firmware for CPU3 is programmed to simplify control of the analog sensor unit, 7-segment display unit, and LCD unit.

A miscellaneous input to the display control unit is the cassette position sensor. This sensor is simply an open or closed switch that will be high when the switch is open and low when the switch is closed. The output from this sensor is fed to pin PD7 of CPU3.

An additional miscellaneous input to the display microprocessor is a signal from comparator U414 pin 7 which provides a back-up indication of battery voltage for low/dead battery alarm status at CPU3 PB7.

4.24.4 LCD Unit

The LCD unit consists of a VIKAY VK2218 LCD module and a power control IC (U401) for the back lighting of the display. The LCD module is connected to the display board via a 16-pin connector (J402). The connector's pinout is shown on the schematic for the display board.

A 5K-ohm potentiometer (R402) is used to adjust a voltage divider which regulates the voltage-controlled contrast of the LCD module. The contrast is controlled by a voltage input of 0 - 1.7 volts.

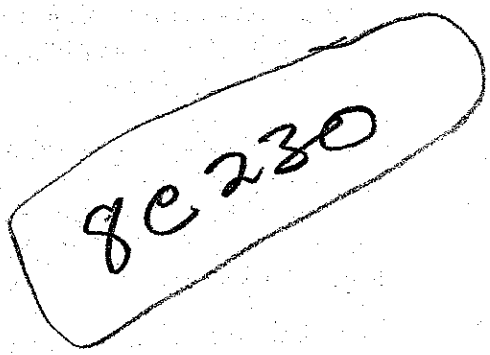
The manufacturer specifies the life of the display at 3000 hours. The backlight may be noticably dimmer as the display life progresses, and continuous use of the backlight option will result in early display replacement. Use the backlight option only when required.

4.24.5 Pressure Plate Position Sensor

This sensor provides information regarding the proper position of the cassette housing and pressure plate within the pump's mechanical system. The sensor is a microswitch that activates when the pressure plate comes within a specified distance from the cassette housing (when a cassette is in place). The switch connects to the display board at P403.

4.25 RS232 Interface

The RS232 Interface is physically located on a small daughter board which is connected to the CPU/Power Supply board via connector J1. The interface is also connected to the external 9-pin connector, located on the back of the pump. This module converts TTL data transmitted by CPU1 into RS232 levels, and converts received RS232 level data to TTL levels. This module also provides 1500V isolation to all signal connections. The hardware port consists of 5 signals, Data In, Data Out, Ground, and hardware handshaking signals RTS and CTS.



Section 5: Maintenance

5.1 Service Information

NOTE
The information and procedures presented in this section apply only to products sold in the U.S. For information regarding products sold outside the U.S., contact your sales representative.

The information and procedures presented in this section are intended to aid the user of the Model 3000 and Micro 3100 Infusion Pumps in achieving satisfactory performance over the life of the pump. However, this maintenance information should not be considered all inclusive. The purchaser is encouraged to contact the 3M Infusion Therapy Service Center when necessary.

Specific training for the 3M pumps is available through periodic seminars. Arrangements for training, a recommended replacement parts list, and any additional service information may be obtained by telephoning 1-800-752-7867. Written correspondence should be addressed to

3M Infusion Therapy Service Center
3M Health Care
3796 North Dunlap
St. Paul, MN 55112

To order replacement parts, contact Customer Service at 1-800-237-8033.

5.2 Materials Return Procedure

NOTE
All product returned to 3M must be preauthorized by the Service Center. Only those products which have been assigned a Returned Material Authorization (RMA) number will be accepted for return.

NOTE
The materials return procedure listed here is intended for use by technical personnel in the USA. Materials return procedures for countries other than the USA may be different. Contact your sales representative for specific return procedures.

The following procedure must be used if it becomes necessary to return 3M equipment for servicing. This Returned Material Authorization procedure is provided so that all equipment returned is properly handled and your concerns receive prompt attention.

To initiate service and repair:

A. Contact the 3M Infusion Therapy Service Center at

   1-800-752-7867

   Request a Returned Material Authorization (RMA) number. A purchase order will be requested before the Service Center will issue an RMA number.
B. Clearly reference on all shipping documents:
   - RMA number
   - Purchase order number
   - Written description of problem
   - Name and phone number of contact person within your hospital or organization.
   - complete name and return address of organization
C. Carefully package the pump(s) in the original shipping carton, or other appropriate container, and affix a 3M "Returned Material" label to each carton shipped.
D. Ship the pump(s), freight prepaid, by traceable means, to:

   3M Infusion Therapy Service Center
   3M Health Care
   3800 North Dunlap
   St. Paul, MN 55112

Service and repair is generally completed within 4 working days following receipt of the pump(s) by the service center. If you need a "service loaner" while your pump is being repaired, a loaner request must be made when calling in for the RMA number.

Any chargeable repairs on pumps under warranty or contract, or repairs estimated to exceed $150.00 on pumps out of warranty, will not be performed without customer authorization. If an "estimate is required before work is performed", state this when calling in for the RMA number. Pumps under warranty or contract are returned freight prepaid following service or repair. Pumps out of warranty are also returned freight prepaid, however a shipping/handling charge is added to the repair charge invoice. If other than normal means of shipment is requested by the customer, an additional charge is assessed, depending upon the type of shipment requested.

Work performed by the Service Center is covered by a 90-day limited warranty. This warranty covers only that portion of the pump serviced in cases where a complete overhaul has not been performed.

Refer to the warranty statements at the beginning of this manual for a complete warranty statement.

CAUTION
3M Infusion pumps are precision medical instruments. When returning a pump to the Service Center for repair, it should be packaged for shipment in a manner which will provide protection against physical shock or other shipping damage. 3M strongly recommends that pumps only be shipped in the original shipping carton to prevent damage.

5.3 Recommended Test Equipment

The following equipment is necessary for performing the recommended functional and accuracy check. Test equipment listed carrying a 3M part number is available from Customer Service by calling 1-800-237-8033.

1. An air regulator which ranges from approximately 2 psi to 12 psi (Bellofram 10-B or equivalent). Order 3M part number 26-1006-5194-7.

   An in-line digital pressure meter with a minimum range of 0 to 15 psi (BIO-TEK Universal Pressure Meter DPM-2).

   The compressed air source is connected to the lower end of an installed administration set in order to verify the accuracy of occlusion alarm thresholds and valve sealing integrity.

2. A 50 mL burette graduated in 0.1 mL increments is used to verify the ±2% accuracy. The burette must be traceable to the National Institute of Standards and Technology (NIST). Order 3M part number 78-8061-4212-7.

3. A digital stopwatch (Microtimer), with a minimum 2 decimal places (100ths of second) is used to verify rate accuracy.

5.4 Recommended Troubleshooting Equipment

The following equipment is necessary for troubleshooting possible infusion pump malfunctions:

- A multimeter (Beckman 3010 or equivalent) is used to verify AC and DC voltages, battery charging current, resistance, continuity, etc.

- An oscilloscope (Tectronix 2213 or equivalent) is useful for electronic signal tracing and viewing various wave forms.

- A regulated DC power supply (B&K 1601 or equivalent) is used to power the pump when the AC power cord and battery are both disconnected. The power supply must be capable of providing at least 2 amperes at 12 volts. Output must be adjustable to 0.01 volt increments (a 2K ohm trimpot placed in a series with the power supply's voltage adjusting component yields fine voltage adjustment). The power supply is used in place of the pump's battery when testing battery voltage trip points. DC voltage is varied to simulate decreasing battery voltage.

- A ground tester is used to test ground resistance.

- A digital Safety Analyzer (Bio-Tech Model 170 or equivalent) is used to measure leakage currents.

5.5 Special Tools

The following tools may be needed to repair 3M infusion pumps, and may be ordered from Customer Service either separately, or as part of a complete service tool kit. To order, contact Customer Service at 1-800-237-8033.

Tool Description	Part Number
Service Tool Kit	78-8061-4214-3
Tool Pouch	26-1002-1834-1
Torx Bit Handle	26-1006-5175-6
T7 Torx Bit	26-1006-5171-5
T7W Torx Bit	26-1006-5172-3
T10 Torx Bit	26-1006-5173-1
T15 Torx Bit	26-1006-5174-9
Keypad Tool	78-8061-4215-0
C-Ring Tool	26-1006-5193-9

Not included in kit. Please order separately:

Safety Clip/Flex Wedge Alignment Fixture	78-8077-8410-9

Periodic Maintenance

5.6 Cleaning

The Model 3000 and Micro 3100 pumps may require periodic cleaning. Cleaning should be accomplished with the pump's AC power cord unplugged and the pump turned off, and by using a sponge or cloth lightly dampened with warm water and an approved cleaner/disinfectant (see Table 5-1).

CAUTION
Excess moisture may damage the pump. Always clean the inside surface of the door, door latch, and the modular connection. When possible, clean spills immediately and thoroughly to avoid sticky buildup.

Table 5-1 Recommendations for Cleaning Agent's on 3M Pump Exterior

I. Cleaning and Disinfecting Products

1. Soap

3M Infusion Therapy recommends using only soap and water solutions (such as Ivory Brand Liquid Soap and water) to clean the outer surfaces of the pump. These solutions have little disinfecting and sterilizing properties.

2. Quaternary Ammonia Salt-Based Solutions

Quaternary ammonia salt-based solutions are typically liquid concentrates mixed with water, and are used for routine wipe-down to clean and disinfect. **These solutions may be effectively used for routine wipe-down of 3M pumps with no adverse effects. Use as directed in Section II, Cleaning Procedures, below.**

3. Alcohol Solutions

3M recommends that only 70% concentrations of isopropyl or ethyl alcohol in water be used in cleaning and disinifecting 3M Infusion Pumps. 3M further recommends that solutions of methyl alcohol never be used in cleaning 3M pumps. Use as directed in Section II, Cleaning Procedures, below.

4. Bleach Solutions

Bleach solutions diluted to 1 part bleach to 10 parts water (approximately 0.5% solution) may be effectively used for routine wipe-down of 3M pumps with no adverse effects. Care should be taken to use only the concentration recommended (1/10) or adverse effects to pump may occur. **Use as directed in Section II, Cleaning Procedures, below.**

5. Activated Dialdehydes

Activated dialdehydes are used to disinfect and sterilize medical instruments by immersing them in these solutions. As immersion is required for these cleaning products to be effective, **3M recommends that they not be used on 3M infusion pumps.** Immersion of 3M pumps in any liquid will have harmful effects on the electronic system.

6. Phenol Based Solutions

Phenol based solutions are routinely used to clean and disinfect. They come in various forms, such as liquid concentrate and aerosol sprays. However, **long-term use could have harmful effects on the 3M pumps, and are therefore not recommended.**

7. Synthetic Detergent with Emulsifiers

These cleaning agents are commonly used for routine wipe-down to clean and disinfect. However, **long-term use could have adverse effects on 3M pumps, and they are therefore not recommended.**

8. Iodine-Based Solutions

Products such as Betadine and Wescadine are commonly used as microbial skin preps. **Long-term use may have adverse effects on 3M pump and they are therefore not recommended.**

9. Turpene-Based Solutions

Products which contain Turpenes **have adverse effects on 3M pumps and are therefore not recommended for use.**

II. Cleaning Procedures

The following cleaning procedures must be followed when cleaning and disinfecting 3M Infusion Pumps.

3M Recommends that you Always:

- unplug the power cord before cleaning to avoid any electric shock hazard;
- apply solutions indirectly using a damp cloth;
- wring out any excess fluids from the cloth or sponge before wiping the pump or power cord;
- open door to clean cassette housing and inside surface of door;
- wipe spills off immediately to avoid sticky build-up.

3M Recommends that you Never:

- immerse pump in liquids - it has potentially harmful effects on the electronic system;
- use steel wool, metallic bristle brushes, plastic abrasive scouring pads, metal spatulas, or other cleaning utensils to avoid scratching pump housing;
- apply solutions with a trigger sprayer or under a direct stream or shower; this helps keep surface moisture to a minimum and protects against damage to the electronic system.

III.Chemical Decontamination Procedure

Hospital protocol may require pumps used in treatment of hepatitis, AIDS, or quarantined patients to undergo special disinfection procedures. Such procedures are likely to include prolonged (10 minutes or more) contact with disinfecting procedures. Special care must be taken to avoid excess solution invading the pump's internal components. Those solutions listed in Section I as not being recommended for use should be especially avoided during decontamination.

IF 3M PUMPS ARE EXPOSED TO PRODUCTS, SOLUTIONS, AND PROCEDURES OTHER THAN THOSE RECOMMENDED BY 3M, ALL PUMP WARRANTIES ARE VOID, AND THE USER MUST ASSUME THE RISK OF ANY PUMP DAMAGE WHICH MAY RESULT. SUCH DAMAGE IS NOT COVERED BY THE 3M INFUSION THERAPY LIMITED ONE-YEAR WARRANTY.

5.7 Recommended Twelve-Month Functional and Accuracy Check

3M recommends that this Functional and Accuracy Check be performed approximately every twelve months. A sample check list is provided as a record keeping suggestion (see Figure 5-1). For brief loading and operating instructions, see Section 3.6. Provide a suitable drain for expended fluid. Use only a 20 drops/mL, non-checkvalve set. Verify the pump is in Primary before beginning.

DANGER
To avoid injury to or death of your patient, never perform these checks while pump is in use by a patient.

To begin:

Press and hold ***Options***, then press ***On/Off***.
Enter ID ***3031***.
Enter Password ***7867***.

1. Record pump history

Record Any System Error/Warning Codes.

Advance through options screens by pressing ***Options***, recording the following information:

- Pump history: Hrs _____ Liters _____ Load _____
- Charge history: AC _____ Charge _____ Batt _____

Advance to Battery use screen and record the information (press ***3*** (↑) or ***1*** (↓) to move within battery use screen).

- Battery use: 0-1 hr _____ 4-5 hr _____
  1-2 hr _____ 5-6 hr _____
  2-3 hr _____ 6-7 hr _____
  3-4 hr _____ 7+ hr _____

2. Audio Alarm Test

- Press ***Options*** and advance to ALARM TEST screen; press number keys ***1***, ***2***, and ***3*** to test alarms. The ***non-insistent*** alarm is initiated by pressing ***1***; the ***insistent*** alarm is initiated by pressing ***2***; the ***BackUp*** audio alarm is initiated by pressing ***3***.
- Turn pump off.

3. Power Up and Self Test

- With AC power applied, verify green (charge) LED lights.
- Turn pump on and verify all LEDs light, and all segments in rate and volume to be infused display areas are lit briefly (8s will appear in all digits).
- Verify hold LED is lit constantly, and Primary LED is lit.
- The Message Display briefly shows a checkerboard pattern, backlight is on, and then display reads:

```
____ mL
this infusion
```

NOTE
The green charge LED will light only when pump is plugged into an AC outlet.

4. LCD Contrast & LED Brightness

- Verify Message Display screen is readable from an angle of approximately 20 degrees (above and below).
- Cover photosensor; verify LED display intensity decreases. Uncover photosensor, and LED display intensity should increase.

5. Keypad/Memory Check

- Load pump with a fluid filled administration set.
- Verify Primary LED is lit.
- Program a rate of 56.7 mL/h and a volume to be infused of 123.4 mL.
- Press ***Secondary***, and verify that secondary LED lights.
- Program a rate of 990 (99.0 on Micro 3100) mL/h and a volume to be infused of 8.9 mL.
- Press ***Run***; disconnect pump from AC power. Verify there is no loss of power or disruption of operation.
- Verify volume to be infused display decreases by 0.1 mL increments, and volume shown in Message Display (mL this infusion) increases by 0.1 mL increments.
- Verify pump switches to Primary after 8.9 mL have been infused in Secondary. Verify primary LED lights, two repetitions of ***non-insistent*** audio alarm sound, and Message Display backlight flashes to coincide with audio

alarm.
- Verify primary rate of 56.7 mL/h and volume to be infused of 123.4 mL are displayed.
- Verify volume to be infused display decreases by 0.1 mL increments, and volume shown in Message Display increases by 0.1 mL increments.
- While pump is running, press ***On/Off*** and verify pump will not turn off.
- Press ***Hold***.
- Observe rate and volume to be infused values. Turn pump off, then on, and verify display values return unchanged.
- Press ***Volume to be Infused***, and verify volume shown in Message Display goes to zero, and volume to be infused display goes blank. Wait approximately 10 seconds, and verify both displays return to their original values.
- Press ***Volume to be Infused*** twice; verify Message Display value goes to zero, and volume to be infused display returns to original value (123.4 mL).
- Press ***Secondary*** and verify "8.9 mL this infusion" appears in Message Display, rate is 990 (99.0 on Micro 3100) mL/h, and volume to be infused display is zero.
- Press ***Primary***.

6. Keypad Lockout Button Check

- Press ***Run***. While pump is running, press Keypad Lockout button on rear housing (located below audio volume knob).
- Verify all front panel controls are inactivated, including ***On/Off***.
- Verify "Keypad Locked" appears in Message Display.
- Press Keypad Lockout button, then press ***Hold***; verify pump enters hold. Press ***Run***.

7. Door Open and Loading Check

- While pump is running, open door and verify

```
Door Open
```

appears in Message Display and ***insistent*** audio alarm sounds. Press ***Silence***.
- Remove administration set from pump, close door, and press ***Run***. Verify

```
Close Clamp!
Load Safety Clip
```

appears in Message display and ***insistent*** audio alarm sounds.
- Press ***Silence***.

NOTE
To avoid possible pump and/or set damage during the next step, close the door slowly.

- Open door and reload set with safety clip in its correct position. Before closing door, close upper tubing clamp. Close door and verify

```
Loading problem
Check tubing set
```

appears in Message Display, and ***insistent*** audio alarm sounds.
- Press ***Silence***.
- Open upper tubing clamp, open door, and load set properly.
- Close door and press ***Run***. Verify pump operates without alarm.
- Press ***Hold*** and turn pump off.

8. Over Pressure Valve Integrity Test

- Press and hold ***Options***, then press ***On/Off***.
- At `Enter ID` screen, enter ***3031***.
- At `Enter Password` screen, enter ***7867***.
- Press ***Options*** until `Pressure Calibrate` appears in display.
- Lower end of the tubing to floor (approximately 30 inches below pump).
- Program 100 (99.0 on Micro 3100) mL/h rate, and run pump until fluid is flowing from end of tubing. When motor position value (left side of screen) is 1650 ±50, press ***Hold***. Watch end of tubing for 30 seconds to verify no more than 1 drop is expelled.

9. Valve Integrity Test

- Connect regulated compressed air source (see Section 5.3, number 1) to lower tubing.
- While maintaining motor position value from step 9 (1650 ±50, top valve occluded) apply 12 psi backpressure to tubing. Verify that no fluid/air movement in tubing occurs (allow tubing expansion created by backpressure to stabilize).
- Run pump until motor position value is 700 ±50, (middle valve occluded).
- Press ***Hold***; verify no fluid/air movement in tubing occurs (allow tubing expansion created by backpressure to stabilize).

10. Pressure Plate Position Sensor Breakopen Point

- Reduce backpressure to below 5 psi.
- Run pump until motor position is 1650 ±50; press ***Hold***. Verify cassette position number (right side of screen) is 1.
- Increase backpressure until position number changes to 0 (breakopen). Verify that breakopen pressure is 6.5 psi or greater.
- Turn pump off and decrease backpressure below 1.5 psi.

11. Check Occlusion Settings

Reference Figure 5-14 for the following discussion.
- Turn pump on.
- Program volume to be infused of 8888 (888.8 on Micro 3100) mL. Leave rate at 100 mL/h (99.9 mL/h on Micro 3100).

Figure 5-1 Functional and Accuracy Check

(recommended Interval: 12 months)

Date_____ **Model #**_____ **Serial Number**_____

Other ID#_____

Function			Notes
1.	Record Information	_____	
	Error Warning Code	_____	
	Pump History		
	Hrs	_____	
	Liters	_____	
	Load	_____	
	Charge History		
	AC	_____	
	Charge	_____	
	Battery	_____	
	Battery Use		
	0 - 1 Hr	_____	
	1 - 2 Hr	_____	
	2 - 3 Hr	_____	
	3 - 4 Hr	_____	
	4 - 5 Hr	_____	
	5 - 6 Hr	_____	
	6 - 7 Hr	_____	
	7 + Hr	_____	
2.	Audio Alarm	_____	
3.	Power Up/Self Test	_____	
4.	LCD Contrast/LED Brightness	_____	
5.	Keypad/Memory	_____	
6.	Keypad Lockout Button	_____	
7.	Door Opening/Loading	_____	
8.	Over Pressure Valve	_____	
9.	Valve Integrity	_____	
10.	Pressure Plate Sensor Open	_____	
11.	Occlusion Alarm Pressure Settings	_____	
	Low		
	Medium	_____	
	High	_____	
12.	Motor Torque	_____	
13.	Empty Bag	_____	
14.	Air Detect	_____	
15.	KVO/Accuracy	_____	
		_____	

- Press ***Occlusion Alarm Setting*** until Message Display is

```
Low Occlusion
Alarm Setting
```

- Press ***Run*** and slowly increase backpressure. Verify

```
Occlusion
below pump
```

occurs at 2.0 psi (+1.0/-0.5 psi)

NOTE
Increase air pressure at a rate of 0.1 psi/3 seconds.

- Press ***Silence***; lower backpressure below 1.5 psi.
- Press ***Occlusion Alarm Setting*** until Message Display shows

```
Medium Occlusion
Alarm Setting
```

Repeat above step and verify pump alarms

```
Occlusion
below pump
```

at 5 psi (±1.0 psi).
- Press ***Silence*** and lower backpressure below 1.5 psi.
- Press ***Occlusion Alarm Setting*** until Message Display shows

```
High Occlusion
Alarm Setting
```

Repeat above step and verify pump alarms

```
Occlusion
below pump
```

at 10 psi (± 1.0 psi).
- Press ***Hold***.

NOTE
If pump alarms outside of specifications listed, see Section 5.10, number 6, for occlusion pressure adjustment procedure.

12. Motor Torque Test

- Program 35 mL/h rate (35.0 mL/h on Micro 3100).
- Press ***Occlusion Alarm Setting*** until

```
High Occlusion
Alarm Setting
```

shows in Message Display.
- Apply 9 psi air pressure to lower tubing and press ***Run***. Verify motor operates without binding ("System Error" in Message Display and ***insistent*** audio alarm) for delivery of at least 6 mL.
- If motor fails to meet test, see Section 5.10, number 9 for calibration and adjustment procedure.
- Press ***Hold*** and disconnect compressed air source.

13. Empty Bag Check

- Program a 999 mL/h rate (99.9 mL/h on Micro 3100). Press ***Run*** and hang solution container so water level in bag is 12 inches above top pump. (Top of pump is defined as flat area below handle.) Verify no alarms occur before pump has infused 6 mL.
- After pump has infused 6 mL, lower container so water level is 2 inches above pump. Verify pump alarms

```
No flow
above pump
```

before 3 mL is infused.
- Press ***Silence***.

14. Air Detect Alarm

- Press ***Run*** and invert administration set drip chamber to introduce air into upper tubing. Verify pump alarms

```
Air In Cassette
```

when air reaches the upper cassette chamber. Remove air.

15. KVO Alarm, Volumetric and Rate Accuracy

Prior to beginning accuracy testing on 3M pumps:
- Obtain a clean 50 mL burette (see Section 5.3, number 2). Place burette on burette stand.
- Obtain test solution. Only sterile water or normal saline may be used. Verify that test solution is at room temperature (70°F ±5°F).
- Hang solution container so fluid level in container is 18" above top of pump.
- Connect 50 mL burette to lower tubing.
- Press ***Run*** and operate pump until bottom of fluid meniscus is even with lowest graduation line of burette. Press ***Hold***.

NOTE
Fluid in burette forms a slight arc. This arc is called the meniscus. All burette readings should be taken from the bottom of the meniscus.

Accuracy Test:
- Press ***Volume to be Infused*** and enter a volume limit of 49 mL (25.0 mL on Micro 3100). Press ***Rate*** and enter 999 mL/h (99.9 mL/h on Micro 3100). Press ***Run***.
- After pump delivers 49 mL (25.0 mL on Micro 3100), verify

```
KVO __mL
this infusion
```